PATTERN-MAKING

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PATTERN-MAKING FOR ENGINEERS

A Practical Treatise

WITH AN APPENDIX OF TABLES FOR REFERENCE

BY

J. G. HORNER

Eighth Edition, Enlarged

BY

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PREFACE

In this book an endeavour has been made to present a very important subject in a comprehensive and practical manner.

Some knowledge of foundry practice, which, if actual experience is impracticable, can be acquired by the study of a good book on the subject, is essential if a pattern-maker is to construct patterns which will prove economical in the foundry. The necessity for this knowledge is, however, to a great extent removed where he is provided with complete drawings of the required patterns.

Although quite satisfactory work can be produced with a limited kit of joiner's tools, pressure of competition makes it imperative that, in the large works at least, advantage be taken of the latest developments in woodworking machinery (such as that illustrated in Chapter XXIX, and in Plates I to XVI), and it is urged upon the ambitious craftsman to make himself fully acquainted with these.

The class of work dealt with in this book is believed to be sufficiently varied to prove instructive in the various branches of pattern-making, and while the apprentice will certainly study it with advantage, it is hoped that the practical pattern-maker, the foundry man, the draughtsman, the designer, and those comprising the works executive will not peruse it in vain.

Unlike many crafts, the underlying principles of Pattern-making have not been affected by the march of time. This, however, cannot be said of the actual manipulation of timber and metal from which patterns are made.

Tools, Machines and Methods have improved, and to keep abreast of such developments this Eighth Edition has been enriched by new illustrations which will prove instructive, and a number of text illustrations have been redrawn.

PHILIP GATES.

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a minor one, in some cases, is the retention of the maximum strength of the pattern. To part patterns costs rather more than to make them solidly, but the moulder's work is lessened when the pattern joints coincide with the mould joints. Depth alone does not render jointing necessary, but the presence of portions in top and in bottom does. In a plain, properly tapered article no middle joint is required either in pattern or mould, even though the piece may be several feet in depth, because there is a straight, easy lift from the sand. But suppose an octagonal section: for this the mould must be jointed along the central axis, and it is well that the pattern should be similarly jointed, since the sand in the top half would become broken if lifted off an unjointed pattern. A circular section is a case in which both solid and jointed patterns are commonly used, even though the mould must be jointed. The reason is that there is little risk in lifting the top sand from off a semicircular section, since there is no perpendicular edge to cause fracture of the sand during delivery. Plain patterns, therefore, of this section are often unjointed. A solid pattern is less likely to twist and go out of truth than a jointed one is. As a rule, large patterns for permanent service are jointed, but those of small dimensions are commonly made solidly, and often of metal, and the mould joints are made on plates or on odd sides.

Cores.—A primary matter is the provision made for coring. It does not follow that because holes or hollow portions are required that they must be cored. Many holes will deliver freely if formed in the pattern. The shallower holes are the more suitable from this point of view. Deep and small holes must invariably be taken out with dried sand cores. A dried core is stiffer than one in green sand. The positions and dimensions of cores are usually indicated by their prints, the latter having in plan the same section as the core that fits the impression. Long, slender cores, set vertically, require deeper prints than large, shallow cores do. Cores set horizontally have prints without taper. If their holes lie below joint faces, pocket or drop prints are used, the lower portion only of which fixes the location of the core.

Economising Pattern Work.—While competition demands that every economy, both in material and labour should be practised, it must not be carried out in a short-sighted manner. A so-called economically built pattern can

PATTERN-MAKING.

CHAPTER I.

THE JOINTS IN PATTERNS AND MOULDS

Delivery.—Cores.—Economising Pattern Work.—Examples of Jointing —Taper.—Loose Pieces —Alternative Constructions.

Delivery.—The first fact to notice is that all patterns must be got out of the sand without damaging—*i.e.*, tearing up the sand. That is the reason why faces are made to slope slightly from the perpendicular, why ribs are thinner at the lower edges than at the top. This is the "draught," "taper," or "strip," which is essential to free delivery. When the shape is such that taper will not meet the case, as when a pattern must be wider at the bottom than at the top, or when flanges or lugs occur in the bottom, then loose pieces, or drawback plates, or cores can be used, or down-jointing, the selection depending on circumstances. Again, in those cases where the outside delivers freely while the interior does not, the use of a separate core is generally adopted. The art of the pattern-maker and moulder lies in the application of such general principles to the myriad cases that arise, and which may be complicated by other matters, and herein lies the high value of matured judgment and experience. The best course to adopt in one case is not necessarily the best in all, because a pattern often includes many related parts which have to be delivered in different ways, involving simple withdrawal or loose pieces or drawbacks or cores, and the lifting of some portions in the top, in others withdrawal from the bottom.

Generally, though by no means invariably, the jointing of patterns and that of their moulds coincides. Here the determining factor is the best method of delivery from the mould, and

prove the reverse when it comes to be used in the foundry.

In some cases, skeleton patterns can replace solid ones, open frames can be made for solid plates, striking or sweeping boards can be substituted where large patterns are required. Typical cases which are economical are these: For a large, plain plated casting—say for a tank plate, a floor plate, or a foundation plate, or a weighbridge top—the pattern can be made as an open frame, and the interior be strickled out in the mould. Even though chequers or diamonds are wanted all over the plate, these are readily stamped in the mould by giving a short, narrow strip containing, say, two rows of diamonds to the moulder, who will stamp them in. This system would not be adopted by manufacturers making such articles regularly, but they adopt it for occasional and jobbing orders. Another economy is secured by striking or sweeping up work in loam instead of making patterns or core-boxes of wood. In brief, it consists in providing boards having edges cut to the profile of the pattern or the core required, by means of which a body of loam or of core sand is swept up. Separate pattern parts which could not be formed by sweeping are made separately and affixed to the main body.

Shrinkage of castings is often a source of some trouble, because it varies, and it produces internal strains in articles that are badly proportioned. The presence of thick and thin parts adjacent, if tied, may produce fracture. And few castings, though made from the same pattern, will measure alike. The following examples offer typical illustrations of the preceding remarks :—

Examples of Jointing.—With regard to jointing, the joints of moulds and patterns sometimes coincide absolutely, in others they do not. This is a matter of common sense plus some experience. The sole object in jointing is to permit of the separation of the parts of which the mould is composed, and these have to be separated in every mould that is ever made, with the sole exception of that rough class of work which is cast in open sand, that is, without a top or covering box.

Now as there is no other object in jointing moulds but this, it should be clear that the jointing of patterns is nothing more than a device to assist the moulder in his work. In some cases it is absolutely essential to have partings in patterns in order to permit of their delivery from the sand ; in others, though it is not necessary, it is convenient. To mould a double-flanged

object like Fig. 1, without taking out the space between the flanges with an encircling core, a joint in the pattern is necessary along the plane *a—a*. And here, too, one of the moulder's joints would be made, the other, for the top box, being at *b—b*. To mould a similar object, but destitute of a bottom flange (Fig. 2), no pattern joint is wanted, but the moulder makes one as before at *b—b*, to part the top and bottom of the mould, which parting is necessary, both to permit of the

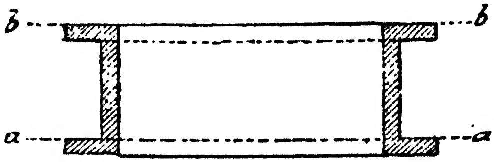


Fig. 1.

withdrawal of the pattern, and the cleaning up of the mould, and if the interior of the frame is cored out, to allow of the insertion of the core.

The articles in Figs. 3 and 4 are illustrative of two different sets of conditions. The first example is one for which the pattern is not jointed; but the moulder makes a joint between top and bottom box parts along *a—a*. Obviously the second figure could only be moulded vertically by making a joint

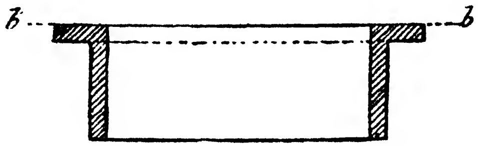


Fig. 2.

along the lower flange of the pattern at *a—a*, and the moulder would have two joints—one there, and one at *b—b*, in this respect resembling Fig. 1. But the rule is that no more joints should ever be made than are necessary, so that this pattern would not be constructed or moulded thus; but one joint in pattern and mould alike is made along *c—c*. In each of these cases the interior is taken out with cores; but that is another matter.

Fig. 4 is illustrative of all pipe and column work, and of the

largest volume of cylinder work done, which is jointed through the longitudinal axis.

There are many cases in which, though the moulder makes a joint, there is no joint in the pattern. Thus a flanged pipe or

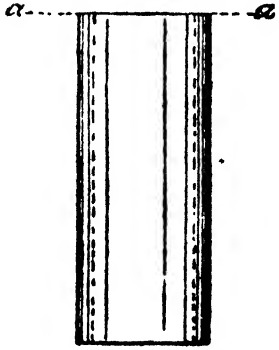


Fig. 3.

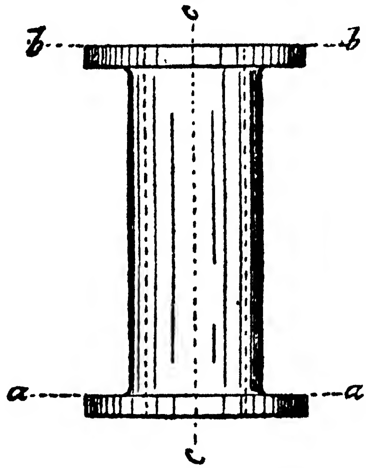


Fig. 4.

column, like Fig. 5, is frequently made solidly, and the moulder joints down, as shown from the plane *a—a* of the joint between the top and bottom box parts to the plane *b—b* of the axis of the pattern. The objection to this is that sand becomes

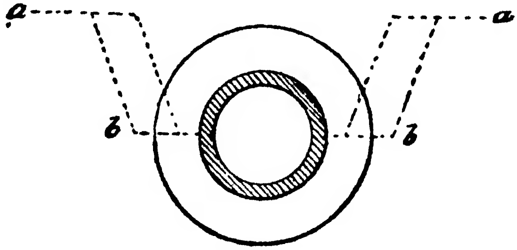


Fig. 5.

torn up in the vicinity of the joint faces *b—b*, and next the flange faces. But the conditions are more favourable when the lift takes place away from a circular body, as in Fig. 5, than from one which is perpendicular, or nearly so, and in these last lifts are avoided when possible.

Thus it would be more desirable to joint the pattern for a square section like Fig. 6 along *a—a* than the round section in the previous figure, the reason being that the halves of the pattern would each be drawn from the mould under the same favourable conditions—a different thing from lifting the mould from the pattern. Actually, however, such a method of jointing would only be adopted when lugs, or brackets, or other excrescences might render such a practice essential. Apart from such cases, the mould would be jointed along *b—b*, or else diagonally along *c—c*. In each case the pattern would be made solidly.

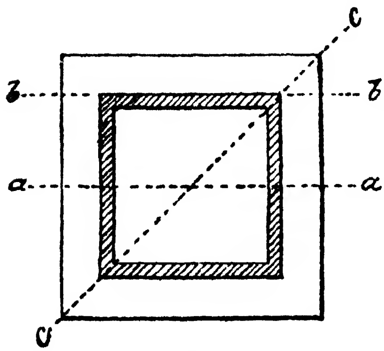


Fig. 6.

Take, now, combinations of cylindrical parts. A four-way pipe (Fig. 7) with or without the flange A, has its mould jointed along the plane *a—a*. But it is almost a matter of indifference whether the pattern is similarly jointed. It is quite sufficient if the top halves of the flanges —namely, those portions which come into the top moulding-box — are left loose to come up into the top. But the addition of a flange, A, makes the leaving loose of that portion in the pattern imperative (coring excepted), and the moulder must make a joint also along the plane *b—b*.

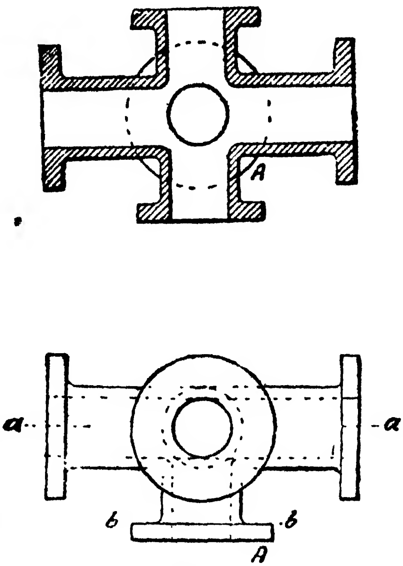


Fig 7.

A common cylinder mould must have two joints, whether moulded with its steam-chest face, or its exhaust face, down-

wards or upwards. If the main joint is at *a—a* (Fig. 8), another joint must be made at *b—b*. If the main joint is at *c—c*, then another is required at *d—d*. And cylinder patterns should invariably be jointed through the centre, because the flanges, branches, and prints offering so many perpendicular faces in close proximity, would break down the sand in the top box if the attempt is made to lift that off a solid pattern.

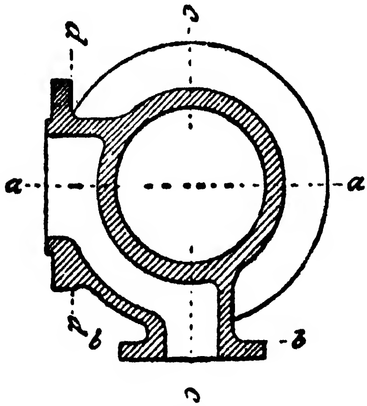


Fig. 8.

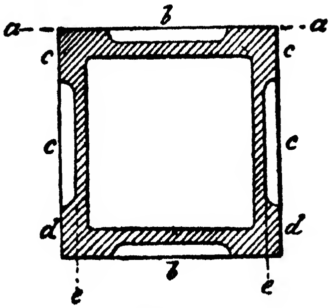


Fig. 9.

Another matter which often comes up is that of panelled or other recessed faces. The square panelled section in Fig. 9 is one in which the mould is jointed along *a—a*, and the pattern is left unjointed. The panel strips at top and bottom, *b—b*, are nailed on the pattern, and so are those, *c*, *c*, at the sides. But the lowermost strips, *d*, *d*, must not be fastened, but jointed

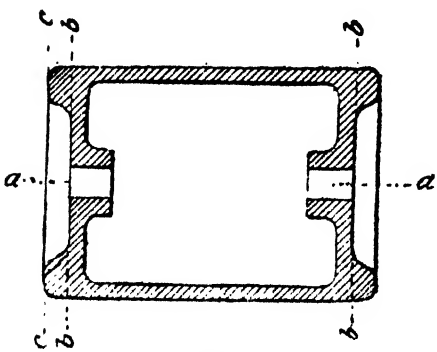


Fig. 10.

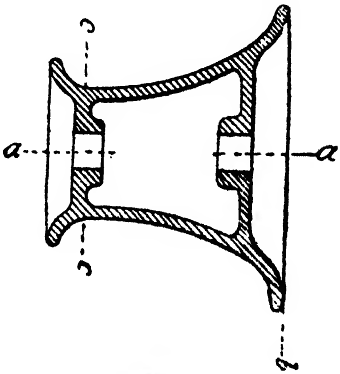


Fig. 11.

loosely at *e*, *e*, to be left in the mould when the rest of the pattern is withdrawn. The roller with recessed ends (Fig. 10), if moulded by jointing along *a*—*a*, will have the overhanging mouldings jointed loosely to the body of the pattern, along *b*—*b*. In this case a good alternative is to mould up and down, in which case the joint between top and bottom boxes would be along *c*—*c*. Then the pattern can be made absolutely solid.

But the next casting (Fig. 11) cannot be moulded solidly on end because of the presence of the flanges. And the recesses are so deep that leaving loose ends is out of the question, if jointing were to take place along the longitudinal axis *a*—*a*. In such a case two courses are open. One is to mould on end, and joint the mould at *b*—*b* and *c*—*c*, and the pattern also at *c*—*c*, the portion between *b* and *c* coming in a middle-part box. Another way, which is not so good, is to joint on *a*—*a*, and make cores to take out the end recesses.

The trolley-wheel (Fig. 12) cannot be moulded from a solid

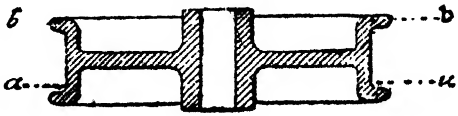


Fig. 12.

pattern, but one flange must be left loose, jointed along *a*—*a*, the top joint of the mould being at *b*—*b*, and the portion between *b* and *a* coming into a middle-part box.

These are a few examples of plain joints, the principles of which are applicable to a vast amount of moulder's work. They do not, however, touch the question of joints of irregular form.

An impracticable method of moulding the bracket (Fig. 13) would be that with the foot uppermost and the bosses downwards. Impracticable, though not impossible, because the bosses A and B would have to be cored over, since they could not deliver by being left loose, and drawn inwards. And provisions would have to be made for their holes with awkwardly located drop prints.

The proper way to mould is in the direction of the arrow, the edge C going down and D in the top. Then the pattern might be made solidly, but better if jointed and dowelled in the plane *a*—*a*. The moulder will then carry his joint round to *b*, the centre of the boss. A radius is inserted at *c* to avoid

the undercutting of the boss A. The hole in the boss A can be cored with two drop prints, that in B with a round print on the lower face. The holes shown in the foot are not cored but drilled. They would cause too much trouble using drop prints.

The bracket in Fig. 14 can be made to mould in one of three ways, each with little special advantage over the others. The pattern may be made unjointed with the rib A downwards, with a curved sand joint from *a* to *a* between bottom and top boxes, so following the curve of the web. If this is done, either the foot C must be left loose or the boss D, because of the under-

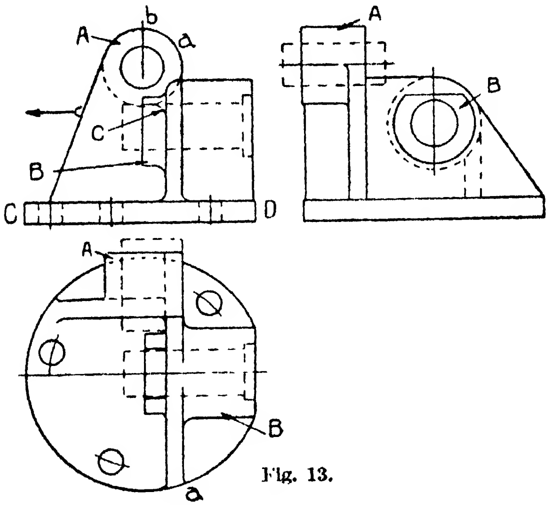


Fig. 13.

cut of the inner edges of the two relatively to each other. Or a portion of the boss D may be jointed loosely, as indicated at *b*. The hole in D may be cored with a round print, but it is better if left to drill. The bolt-holes in the foot can be taken out with drop prints, but they will cost more to core than to drill.

The pattern may still be constructed solidly, but moulded sideways, the sand joint between top and bottom going from *c* to *d* in the upper view. This is not a good method, because a deep lift of sand has to be made up the inner face *e* of the web and the inner face *f* of the flange, against which, the faces being perpendicular and deep, it would become torn up. If the pattern is moulded in this direction it should be jointed

and dowelled either along the centre of the web *g—d* or along its upper face. Moulded thus the planing strips on the foot must be skewered on loosely. I should prefer the first method, described in connection with the lower view, because the width of the web is continuous across its width, being planed to the curvatures and screwed on the rib, and is therefore stronger than if divided in half along the line *g—d* in the upper view.

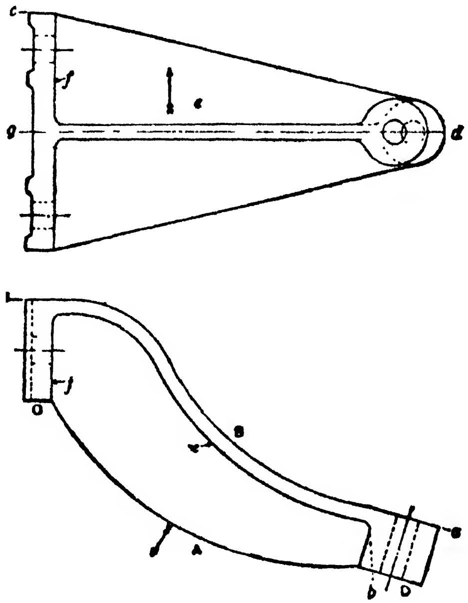


Fig. 14.

There is only one way by which to mould the bracket (Fig. 15), that is on its side A downwards. The question of jointing does not arise, because the bounding ribs are shallow. They will deliver if tapered on the inner faces—say, $\frac{1}{8}$ inch in a depth of 3 inch or 4 inch. On the outside there is only a very slight taper, or none at all, the rapping being sufficient to loosen the pattern from the sand and ensure a clean lift. The mould joint is made along the face *a—a*. A round print is put on the boss for the shaft hole. The hole in the web will deliver itself. If separate bosses are fitted for the bolt-holes in the foot they must be skewered on, but a continuous facing can be substituted and made fast. The bolt-holes will be drilled.

But if the bracket were very much deeper the inner faces of the upper ribs would be so deep at *b* that an excessive amount of taper would have to be imparted to ensure a clean lift. The alternative, then, is that of the upper view in Fig. 14, jointing the pattern along the centre of the web or along the top face of the web. This is adopted in many patterns of which Fig. 15 is typical.

The warping cone (Fig. 16) is a casting that can be made with a choice of several methods, the selection being governed chiefly by the number of castings ordered. The pattern is built up with lagging strips in any case. It may be jointed in halves along the middle plane *a—a*. In that case, end

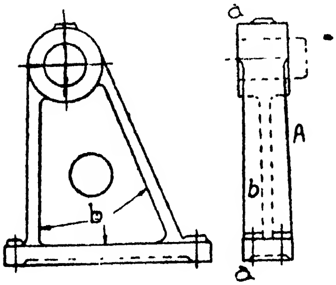


Fig. 15.

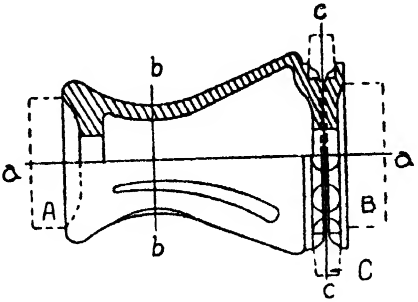


Fig. 16.

prints A, B are fitted to take out the undercut portions at the ends, the shaft holes, and the central body of the core. The recess for the chain must be cored, for which an annular print C is turned, and the core is made in halves to go in bottom and top. The ribs—*whelps*—must be skewered on the pattern loosely, except those which come in top and bottom.

Another way is to divide the pattern along the plane *b—b* to mould vertically, the prints A and B being retained, but tapered instead of made parallel. The ring print C may be retained, and the core be made as a complete ring. Or if the casting should be large, and only one or two required, short segmental cores can be made and set round in the print impression. Yet another method is to mould vertically, still with a joint at *b—b*, but instead of coring the portion for the chain, to cut it in the pattern. A joint is then made along the plane *c—c*. This is the best method to adopt when a large number of castings is required. Sometimes for one or two castings

of large dimensions a loam-pattern body, undivided, of course, is swept up with the prints A, B, and C included, and the ribs are cut in wood and attached to the loam body. The core-box for the chain groove has to be prepared. The central core is swept against the edge of a board.

The warping cone in Fig. 17 is a casting that is differently made, according to the numbers off and the size. The pattern can be parted longitudinally along *a—a*, with prints at each end. The boss, disc, and ribs will be put in a half core-box. The presence of these would prevent the sweeping of the core on a bar. A large box is expensive. To avoid this the pattern can be jointed along *b—b*, and the interior left to deliver itself. The objection to this is the flimsiness of the rim built up with segments. This may be avoided by making a metal pattern

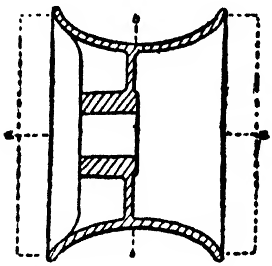


Fig. 17.

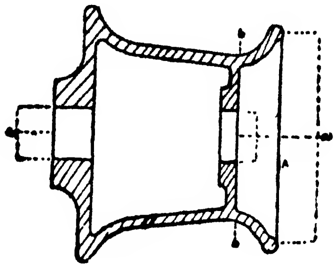


Fig. 18.

for the rim alone, and fitting the disc, boss, and ribs in wood; but this presupposes a considerable number of castings required.

Such a method would be nearly impracticable in the shape (Fig. 18). This can be jointed along the centre *a—a*, with prints as outlined. Another way is to mould with the face A downwards, using a tapered print. But the presence of the disc and boss requires a core-box. A little trouble may be saved by jointing the pattern along *b—b*, leaving the inner portion below to deliver itself; put a print on for the small hole, and rest or check the centre core swept up on that. The core for the upper shaft hole can be checked into this with a print impression, or be swept with it.

The coned crane roller in Fig. 19 might be jointed longitudinally, but it would be a poor method, because the metal in the top would be liable to turn out spongy, and these rollers have to be turned, and must be free from honeycombing.

The proper way is to mould it with the face A downwards, put a tapered print on the boss there and another on the top boss. The interior is rammed in a core-box, or a half box, the numbers being large, and the cores for the holes B, out of which the main core is withdrawn, are rammed on the main core, or set in print impressions in the latter.

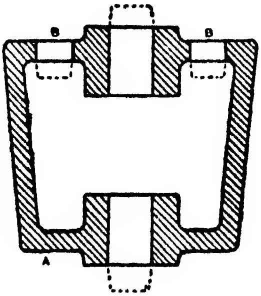


Fig. 19.

Only one way is feasible of moulding the drum in Fig. 20. Its dominant feature is the recessed claw clutch at one end, and the ratchet wheel at the other, full shrouded. Both are formed in cores, for which prints are provided as indicated. The ratchet core is made in halves in a half box for convenience of insertion in bottom and top. The pattern is jointed along *a*—*a*, and the central core is swept on a bar. The clutch core is threaded on an extension of the shaft core at that end before insertion in the mould. This locates the main core centrally there.

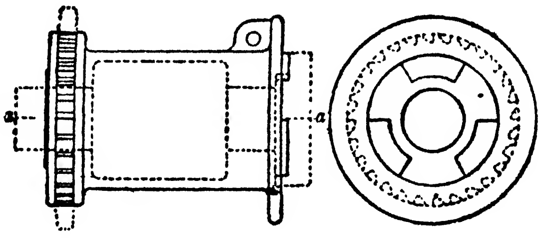


Fig. 20.

The tumbler bracket (Fig. 21) appears to offer two alternatives, but hardly so when looked at closely. That it must be moulded on its side with the face A downwards is without question, because to mould it as in the lower view would either entail leaving loose the ribs and bosses on the sides, or awkward down-jointing. Moulding as in the upper view, the question arises of leaving the upper portion B loosely dowelled on the lower, separated by the curved piece C. But this view will be dismissed, though with a casting of large dimensions it will be feasible.

The only good solution is to mould the pattern sideways, and provide a core print, outlined in the lower view, to take out the interior. In that case the piece B can be dowelled on the top face of the print to lift bodily in the cope, instead of lifting the top sand past the perpendicular edges. The inside bosses and the inner curved portion C will go in the core-box. The oil grooves *b*, *b* will not be cast but tooled. The holes in the bosses are cast, using prints on the lower faces. Those on the portion B may be provided in the box, as indicated, or they may go on the top faces of the bosses. Or round prints may be inserted to occupy the depth of the box, into which round cores will be inserted to pass continuously through top and bottom bosses. The holes *c* and *d* should be left for drilling.

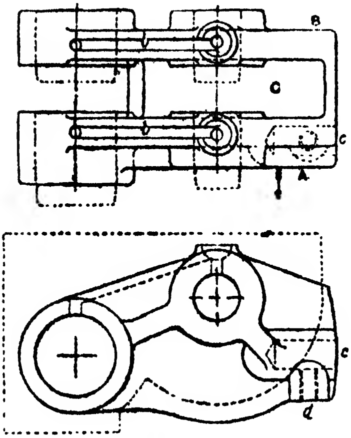


Fig. 21.

Coring is usually the better way of taking out any narrow space, even when it would be practicable to mould directly from the pattern. The core serves as a gauge for the thickness of the spacing, and it leaves a smoother face on the casting. The narrower the space the more reason exists why a core should be employed. Bosses, prints, and other parts can be included in the boxes.

Taper.—Patterns are constructed like their castings, either when no interior portions are present (Fig. 22) or when such portions can be readily delivered from the sand, or, which amounts to the same thing, when the sand can be removed from them. These conditions exist when no parts are undercut in relation to the plane of the lift, and then only when the dimensions of the sand, such as its width or diameter relatively to the depth, are large enough to guarantee coherence in the mass. Thus a hole 1 inch or 1½ inch diameter and 6 inch deep (Fig. 23) could not be delivered by hand-lifting alone, while

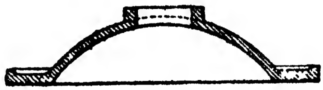


Fig. 22.

another 6 inch diameter and of the same depth (Fig. 24) could be, provided a little taper or reduction in size were allowed.

Taper is thus a most important controlling fact. The moulder likes to have plenty of it, but generally in castings its amount must be very slight. But enough must be allowed to relieve the pattern from the pressure of the sand during its withdrawal, since perfectly parallel edges would bind against the sand as hard and tightly just before delivery as at the commencement of the lift, and that would cause the edges of the sand to fracture or "pull up." In Fig. 24 the pattern

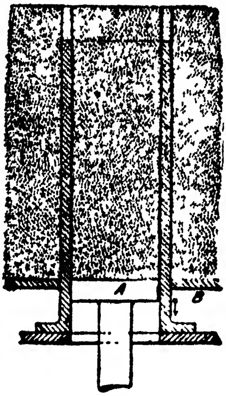


Fig. 23.

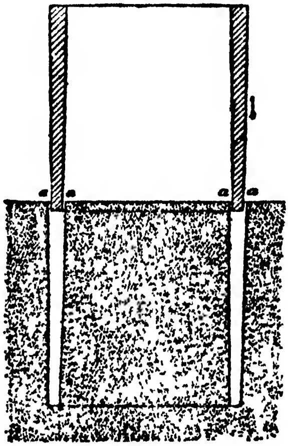


Fig. 24.

is seen just leaving the mould, and the clearance between it and the sand provided by the taper at *a*, *a*, is shown. In Fig. 23 a feature is included by which delivery of a core much longer than that shown can be effected, that of a piston, *A*, supporting the sand against its tendency to fracture by the frictional effect of the pattern, here being drawn downwards. In this case no taper at all is required. Also the sand is sustained against the outside by means of a stripping plate *B*, and here also no taper is necessary. But these are machine methods and do not apply to the ordinary hand-made moulds, which we are now discussing. In Fig. 22 a hole is cast in the cover. This is so shallow that it will deliver easily with a

trifle of taper, so that a core is unnecessary here. It is therefore clear that the conditions which are most favourable to self-delivery are the presence of sloping faces, or of hemispherical, or cylindrical interiors, and not vertical ones, and after that of shallow vertical ones. The more nearly shapes approximate to the sloping or the curved forms the better for self-delivery.

But these broad facts are modified by others. The sides of a pattern may be amply tapered, and still a lift of the sand be undesirable or impracticable. The moulder's axiom that the faces which must have the soundest metal must be cast downwards as at *A*, Fig. 25, also influences methods. In the engine-

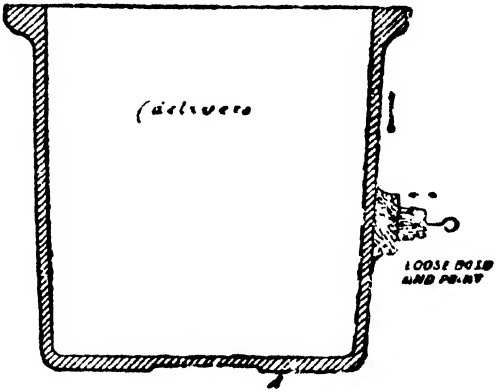


Fig. 25.

base section (Fig. 25) the interior might, and would, be generally lifted out in green sand and the outside of the pattern be withdrawn from the mould as indicated by the arrow, provided other details of the bed did not enter to complicate matters, as they generally do. The bed section taken through the crankshaft bearings (Fig. 26) is one example of this kind. The outside delivers readily enough, but the inside should be cored, if for no other reason than that the sand is both deep and narrow. In Fig. 27 all the interior of the crank chamber will deliver downwards. The sand in the shallow recess above can be lifted with the top box, but the interior of the flanking sides cannot deliver although ample taper is present, because the return flanges *A*, *A*, prevent it. These, therefore, are cored, cores being located by the prints above, assisted by chaplets

elsewhere. In the crank case (Fig. 28) the actual chamber will deliver readily, though it is as often cored as indicated.

Loose Pieces.—Pieces are left loose on the sides of patterns because they could not be withdrawn from the sand, if fast.

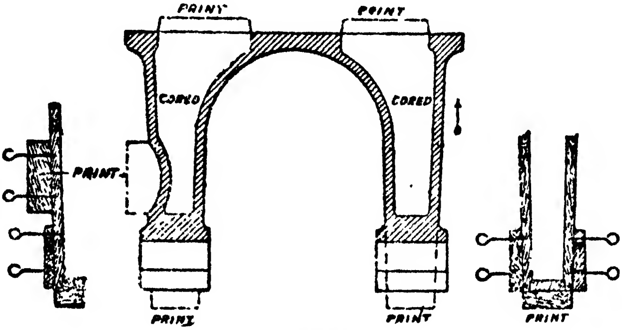


Fig. 26.

Figs. 29 to 31 are typical of these cases. They are only temporarily secured with skewers or wires, or with dovetails, or sometimes when they lie on the bottom face, with dowells. The main portion of the pattern having been withdrawn,

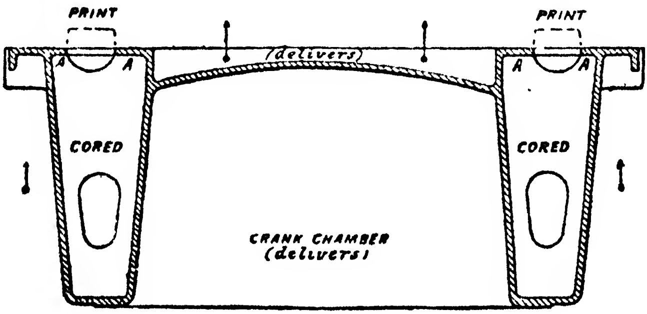


Fig. 27.

the loose piece is left behind to be taken out with a pricker (Fig. 30). Other examples may be noted in Figs. 25, 26, and 28.

Obviously thickness sets a limit to the withdrawal of strips. A strip cannot be thicker than the space through which it has to be withdrawn. It must be less. But a

strip may be divided into two or even three thicknesses, each thickness being withdrawn separately. Fig. 31 shows an extreme case, practicable but undesirable. A moulder would usually prefer to use a drawback here, or to insert a core over the strip. But in Fig. 32 the loose pieces may be very wide, and yet be easy to withdraw, because the space into which they can be withdrawn is many times wider than the strips.

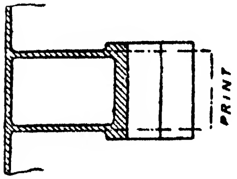


Fig. 33 is an illustration of the employment of loose pieces for convenience only. The pattern-maker is often in doubt as to the desirability of making pieces which come into the top loose. Bosses, unless very shallow, should usually be so treated. In Fig. 33 the middle rib in the top should always be dowelled on loosely, even though it is well tapered. In some circumstances the whole of the ribs in the top should be so treated, but one cannot regard an isolated portion of a pattern without reference to the general construction. Frequently the side ribs would not be loose, but be made fast, and well tapered on the inner faces. This affords a lift on the outside from the top to the bottom without leaving a joint line to show. Of course the alternative is to joint the pattern along the centre of the web, or along the top face of the web, in which cases the upper portion is withdrawn from the cope, an entirely different condition from the lifting of the cope off the pattern.

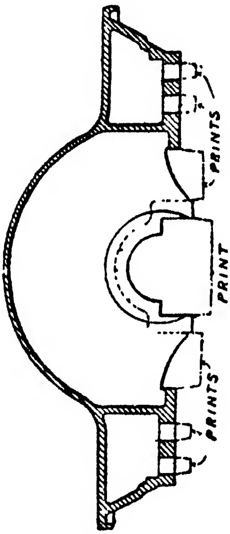
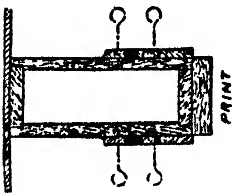


Fig. 23.



Alternative Constructions.—The question of numbers of castings required all alike, or nearly alike, generally determines in the main the methods of the pattern-maker. But dimensions also, whether large, small, or medium, have to be con-

sidered as well. So also have shapes, whether irregular or regular; as, circular, which is admirably suited for sweeping up; or, rectangular, for skeleton or sectional framings; or, irregular, which cannot be so well treated. It is not to be

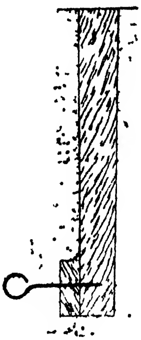


Fig. 29.

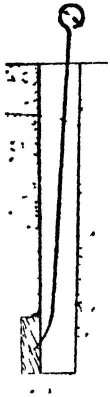


Fig. 30.

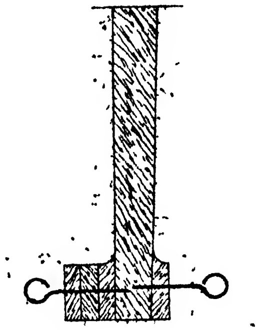


Fig. 31.

marvelled at, therefore, that the idea of different men vary so much as to the most suitable methods of moulding, and of the amount of assistance which should be given to the moulder by the pattern shop, having regard to the relative expenses

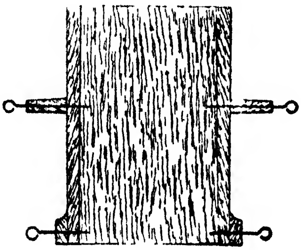


Fig. 32.

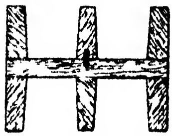


Fig. 33.

of each department. Broad views and due balancing of costs are therefore requisite in the conduct of these departments, which should never be regarded as having isolated interests.

As there are several alternative methods of working to achieve the same results in the ultimate form of castings, we

will consider the broad divisions of work just now instanced, those of numbers off, along with those of dimensions and of shapes, since neither stands in a state of isolation from the others.

The usual method when numbers are required all alike is to mould from complete patterns, made exactly like their castings, save for core prints and cored portions. And as numbers off increase, more care is bestowed upon pattern construction, either in regard to the character of the wood work, or in the abandonment of wood for metal, and also by pressing into service the aids to be derived from mechanical methods of moulding.

In the pattern shop the difference lies in all that is included in the terms "rough patterns," and "standard patterns." This means a great deal in extreme cases. A rough pattern may be broken up immediately it is done with; and when that is to follow, not a penny more is spent on it than is absolutely necessary. More work, of course, is thrown on the moulder, who will have to rub his fillets and the print portions of the cores, and will often have to work with sweeping boards or skeleton core-boxes, or with no boxes at all. Some parts will be fast, instead of being dowelled, and the work will go into the foundry unvarnished, and without rapping or lifting plates, and so will often be provocative of strong language on the part of the moulder.

On the other hand, a standard pattern in its best form will be perfect in dimensions and in finish. All fillets and hollows will be put in, cores will fit their prints without rubbing, every core will be made in its own box ready for use, loose pieces will be fitted where there is the slightest risk of the mould breaking down if they were fast; and they will be so fitted, and the cores also, that it will be quite impossible for a careless moulder to set them in any but their correct positions. There will be no excuse for a moulder to drive his bar or spike into such a pattern for rapping and lifting, since plates or straps will be provided where required. Care will be exercised in the selection of timber, which is protected with three or four coats of varnish or paint, well rubbed down.

Between these extreme cases most patterns are made. Besides these, metal patterns are substituted generally for those of wood in small standard and machine-moulded work.

But as there are many classes of jobs which are never repeated in large numbers, it is here that the debatable ground lies. These jobs include all engine cylinders of large dimensions, large fly-wheels, unusual sizes and shapes of columns, pipes, and bends, large drums for winding and hauling, big pulleys, sheave wheels, and toothed wheels, either of which may be made in one of two or three methods—namely, from full patterns, or in combination methods, by the aid of sweeps in green sand or loam, by the aid of fractional pattern parts, or of moulds in conjunction with such portions or sections of patterns and core-boxes that do not lend themselves to methods of sweeping up. The mere mention of these items will call up to the mind numerous alternatives possible in the production of a mould.

Dimensions also determine methods of working to a large extent. Thus, methods which are practicable with castings measuring from a few inches to 3 feet or 4 feet across are often unsuitable for those of larger sizes, either for economical or other reasons. But in conjunction with dimensions, shapes also exercise much controlling influence in the choice of methods. Any symmetrical article, no matter how large, suggests at once the employment of sweeping up, for which either green sand or dry sand, or loam, are often equally well adapted. And if an object is not wholly adaptable to this method—as, in fact, few are—then it is always practicable to utilise pattern parts or cores to complete the work, whether done in green sand, loam moulds, or with loam patterns.

The alternative methods, therefore, of the foundry may be very broadly classified thus:—Complete patterns made in the ordinary way for hand moulding. Complete patterns in which mechanical aids are utilised. Work which is moulded without complete patterns, which includes skeleton patterns and moulds taken from broken castings, as well as swept work. Also a large class of moulding made from segmental patterns, and sectional patterns in which a combination of several methods is utilised, such as pattern parts, sweeps, and core-boxes together. Lastly, there are devices for making moulds differing in some respects from their patterns, which includes alterations of certain details only; as of patterns in some degree standard, to which supplementary parts may be fitted, or in the moulds, in which stopping-off is done; or both devices may be effected in the same mould in conjunction.

In any of the methods of moulding, in which a complete pattern is dispensed with, there is a larger element of risk present, that of inaccuracy, than there is when a full pattern is employed. This arises in all work that is either swept up or marked out on sand beds, or where pattern parts are bedded in green sand or in loam, or attached to loam patterns. These risks the pattern-maker is expected to foresee and guard against, and to accept responsibility for, even though the carrying through of the work lies in the moulder's hands. As a general rule the pattern-maker has to spend some time in the foundry, more or less, during the progress of such jobs, either marking out centre lines, or measuring-in parts, or checking the mould at certain crucial stages.

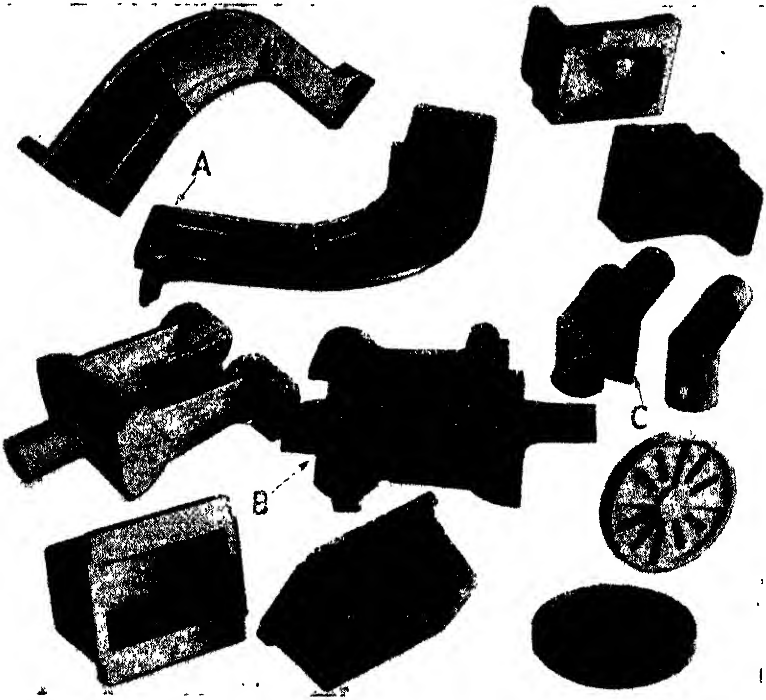


Fig. 33A.—Simple Patterns in Brass, Wood and Bakelite.

These are seen here with the aluminium castings produced from them. Patterns A, B, and C are split through the centre, the halves being located by means of dowels. The box-shaped castings have a very pronounced taper which facilitates moulding. Castings are sold by weight and the price varies with the amount of work involved; thus cored work should be avoided—this saves pattern costs and time in the foundry. Scraps of sheet plastics are very useful when making small temporary patterns.

CHAPTER II.

PRINCIPLES OF PATTERN CONSTRUCTION.

Large plain areas.—Radii.—Curved portions.—Boxing up.—Building up with segments.—Lagging.—Valves and cocks.—Loose pieces—Camber.—Core-boxes.

If a pattern is to retain its shape, the limitations to the use of solid stuff, however well seasoned, are soon reached. The pattern-maker is an adept in so arranging timber grain in varied forms of construction that the shape will be retained unimpaired for an indefinite period, capable of being employed for hundreds of mouldings in moist sand. The illustrations given will show how this is done.

When a large plain area is required, a common method is to lay narrow boards side by side, leaving open joints between (Fig. 34). But this is only suitable when the boards can be retained in place by means of ribbings or other fittings screwed upon them as in Fig. 34. When this cannot be done, a

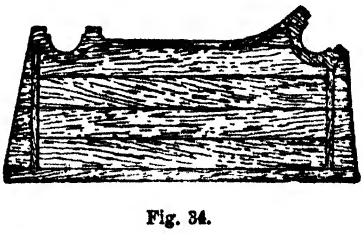


Fig. 34.

frame is made with halved joints, of plain, or of dovetailed form, leaving an open central area. This is either strickled in the sand, or it is filled in with loose boards (Fig. 35). The method

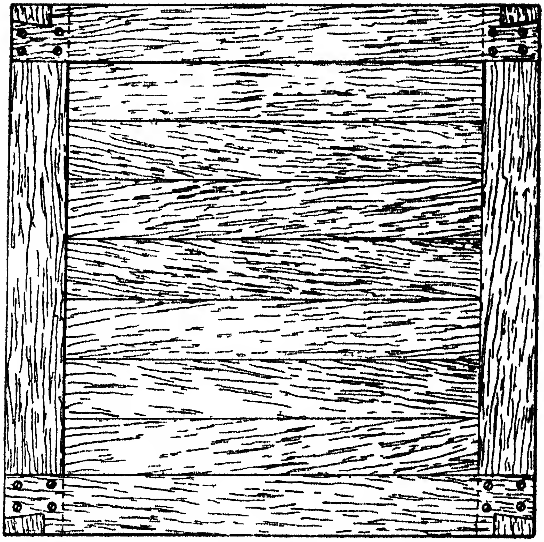


Fig 35.

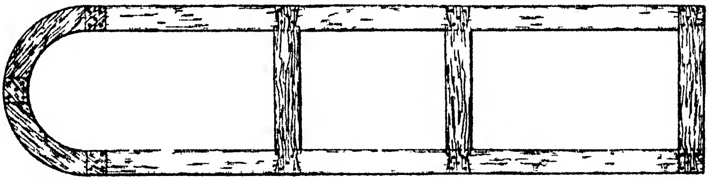


Fig 36

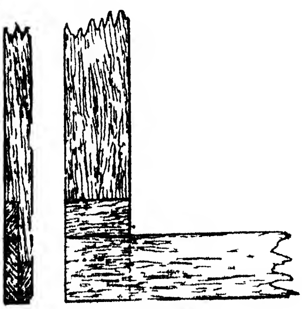


Fig 37.

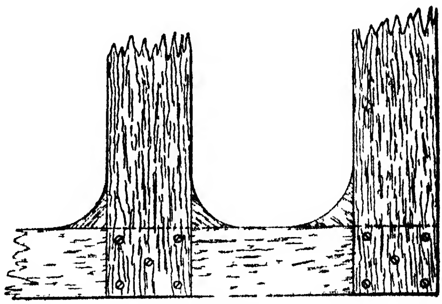


Fig 38.

of halving is seen in Fig. 36. The advantage of the dovetails is that they hold the sides better to the cross-pieces than

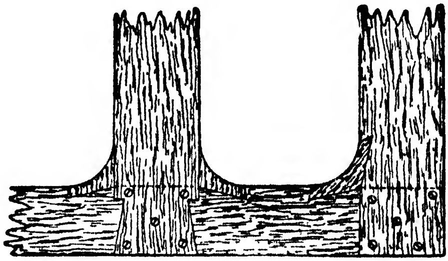


Fig. 39.

plain halvings do. But using plain halvings, a pattern can be extended in the manner shown in Fig. 37.

Radii are fitted in the corners of patterns either as in

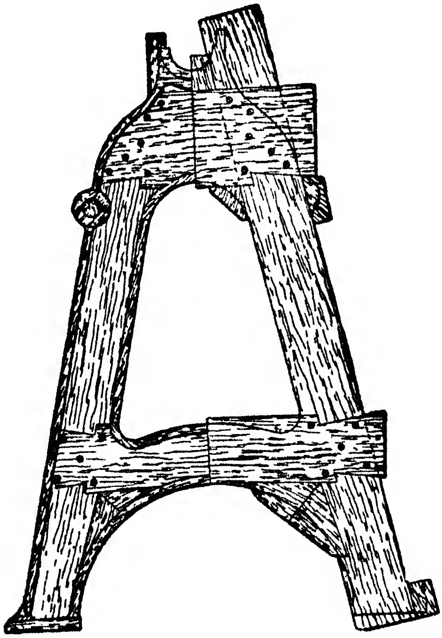


Fig. 40.

Figs. 38, 39, or 40. In Fig. 38 they are simply fitted into the angles with the grain running as shown, two

directions of grain being indicated. In Fig. 39 two methods of letting in of corners are drawn, and alternative directions of grain. The advantage here is that the weak feather edges of Fig. 38 are avoided. In Fig. 40 a complete pattern with dovetailed halvings and with radii fitted,

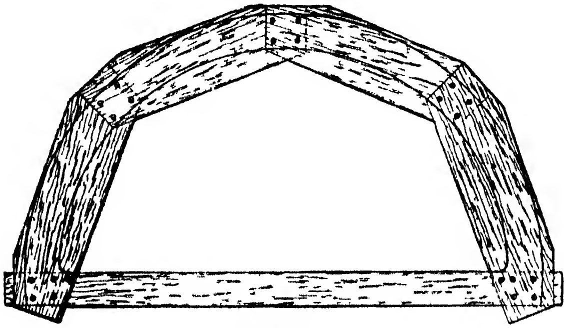


Fig. 41.

and with ribbings cut to give the strongest construction is shown. The right-hand half illustrates the web or plate as

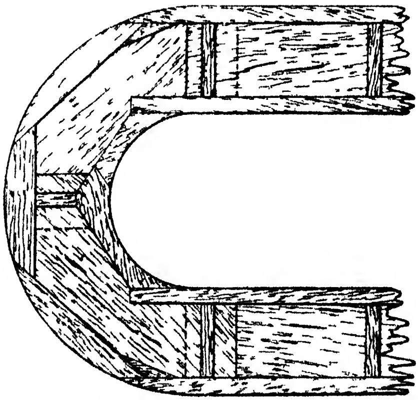


Fig. 42.

fitted and marked out, the left-hand, the pattern as cut and completed with its ribbings.

When a pattern has curved portions of very large dimensions these must be made up in lengths in order to minimise shrinkage and warping. Thus the boiler front in

Fig. 41, halved as shown, will remain accurate for a long time. This is an elaboration of the method of making the semicircular end in Fig. 36.

When semicircular ends are of good depth, as in engine

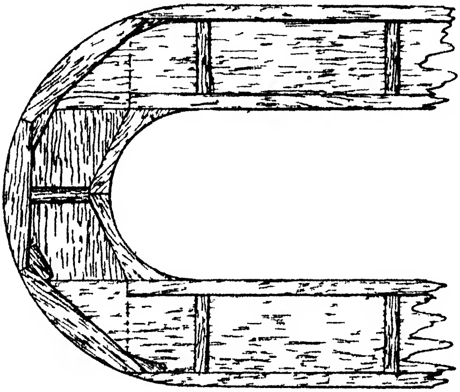


Fig 43

and pump beds and similar shapes, two plates are prepared and the space between is occupied by blocking. This is variously arranged, the object always being to avoid shrinkages. Figs. 42 and 43 show alternative dispositions of the stuff, either being equally suitable. The small angular blockings seen glued in, stiffen the ends and prevent movements of the end joints consequent on ramming and rapping. In Fig. 44 the usual method of forming a large radius at a corner is shown. The longitudinal pieces are screwed to the webs, and angular pieces glued in, and afterwards worked for inner and outer radii.

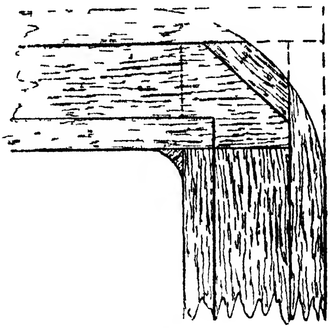


Fig 44.

The proper way to box up deep patterns of rectangular section is that shown in Fig. 45. The sides are prepared to the total depth, and the top and bottom are rebated into the sides and rest on the rebates and on the cross-bars. In the method shown in Fig. 46 the top and bottom, not being

rebated into the sides, are liable to become rammed slightly concave between the cross-bars. In Fig. 47 the edges of top and bottom pieces are likely to overlap after repeated mouldings in the damp sand. In the stores they

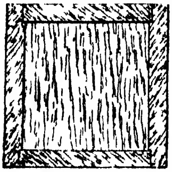


Fig. 45.

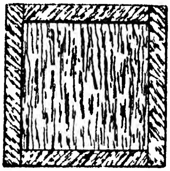


Fig. 46.

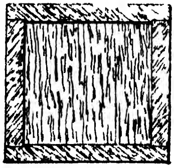


Fig. 47.

are liable to shrink, leaving the sides overlapping. Either event interferes with the delivery of the pattern. But in

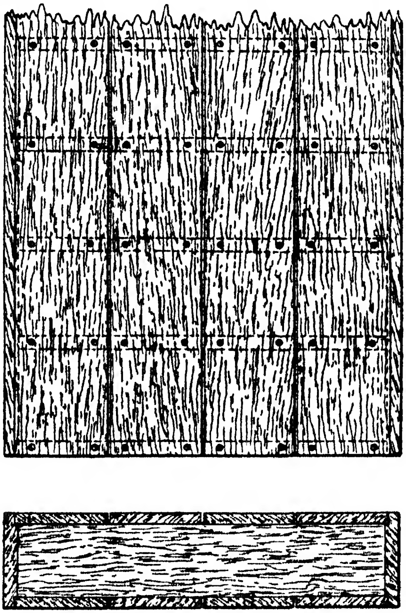


Fig. 48.

jobs like Figs. 42 and 43 the method of Fig. 47 is adopted, and that of Figs. 45 and 46 when the pattern has a plain section. Thus in Fig. 48 a large rectangular pattern is shown made as in Fig. 45. The covering of the

top and bottom is also done with narrow strips and open joints.

When a pattern is very weak it may be reinforced with

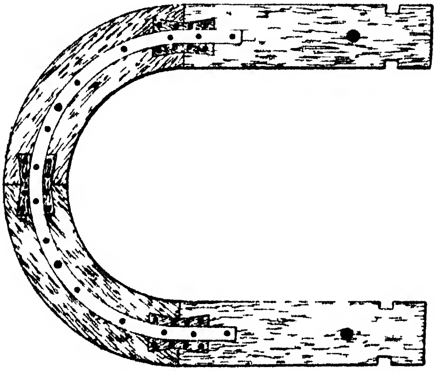


Fig 49.

iron bar bent to the shape. Thus Fig. 49 shows an arched pipe open in the joint. The bend portions have been united to the straight parts with dovetails in the regulation

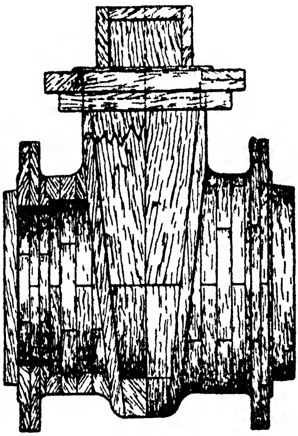


Fig 50.

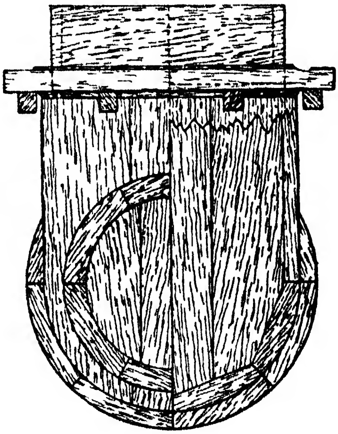


Fig. 51.

fashion. But a piece of bar is also curved and let into each joint face, flush, and screwed. The dowells may be put through the bar or at the side. The bar must be stiff, say

1 inch by $\frac{1}{4}$ inch, or $1\frac{1}{4}$ inch by $\frac{5}{16}$ inch, or $\frac{3}{8}$ inch, depending on the size of the pipe.

The method of building up circular work with segments is illustrated in a heavy sluice valve, in combination with the boxing up of the rectangular portion of the pattern. The main central joint is shown and the loose flanges. The view to the right of Fig. 50 is an external one, that to the left is a section. That to the right of Fig. 51 below the broken lines is a section through the boxed-up body, that to the left is taken through one of the branches. Fig. 52 is a plan view on the face of one flange and its core print. Four courses of segments are used for each branch, and three courses for each flange. Fewer courses would do, but the pattern work would not be so permanent. The oblong flange is jointed with halvings at the corners, except at the top portion which is dowelled. The pocket or drop prints for the bolt holes are seen

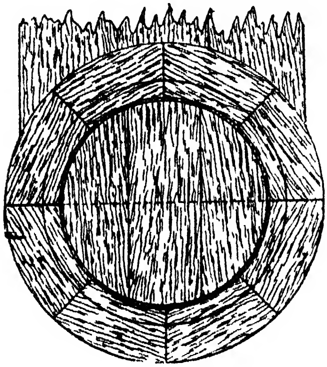


Fig 52.

Cylindrical work outside the smallest diameters is constructed by lagging up, which ensures permanence of form. Fig. 53 illustrates the leading features in this construction.

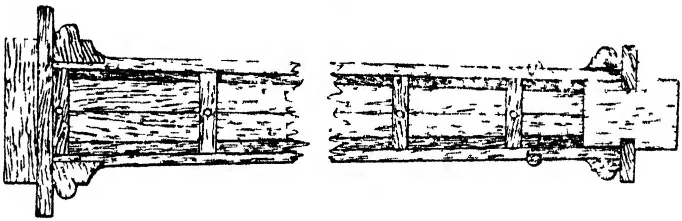


Fig. 53.

The lags are glued and screwed to cross-bars. Whether the lags shall include core prints depends on their relative sizes. They may when the print and body differ only by about $\frac{3}{4}$ inch. But if the difference is greater, a block may take the place of a cross-bar, as shown at the top of the column (Fig. 53), and the print will be turned on this. If the print is much larger, as it is at the bottom, it will be

turned separately and screwed on. Flanges may be let into recesses as at the top, or screwed against an end as at the bottom. Mouldings when small are turned in stuff glued on the lagging, the grain running parallel as at the top, or if large they are made as separate pieces plank-way of the grain, and let into a recess as seen at the bottom.

Valve work affords many illustrations of variety in

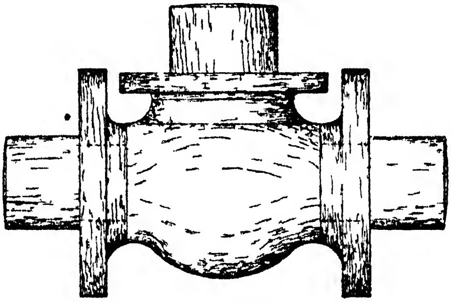


Fig 54.

pattern construction Some of the smaller patterns are cut in solid mahogany, as are those with hexagonal union ends. But

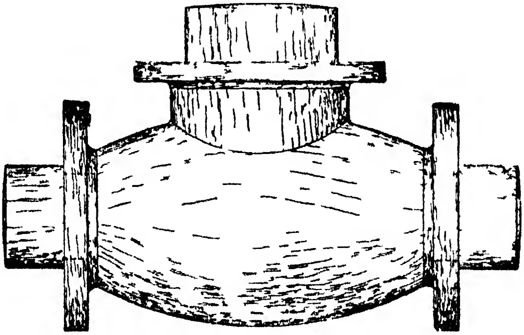


Fig 55.

this method is inadmissible when flanges are used. These must be fitted separately, with the grain in the plane of the flanges. These fit into grooves turned in the body (Fig. 54). In this figure the core print for the mouth of the valve is not turned in the solid as the others are, but separately, to keep the grain running longitudinally. It may be fitted with a stud as indicated, or with a dovetail. In Fig. 55

the same method of fitting the flanges is shown, but the branch which forms the mouth is fitted round the curve of the body. It includes its print, and a recess is turned to receive the flange.

Fig. 56 is a cock pattern in which every portion is cut

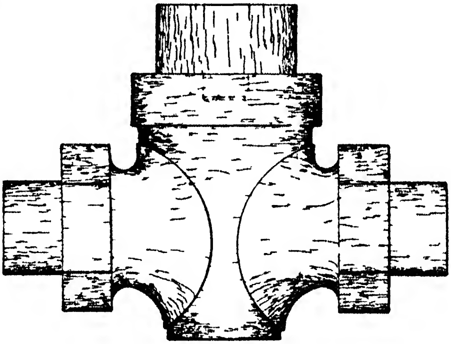


Fig 56

from one piece of solid stuff, excepting the print for the mouth. This is studded on, the object being to lessen risk

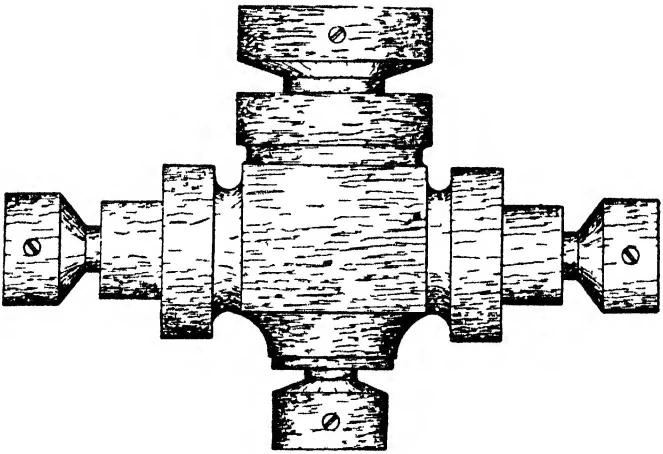


Fig 57

of shrinkage or curving due to excess of width. Fig. 57 shows the pattern as it appears when the whole of the turning has been done, in two chuckings. It is ready to

have the hexagonal ends cut, and the "shield" of the body, and the print for the mouth to be fitted.

Fig. 58 illustrates how a strong job may be made when

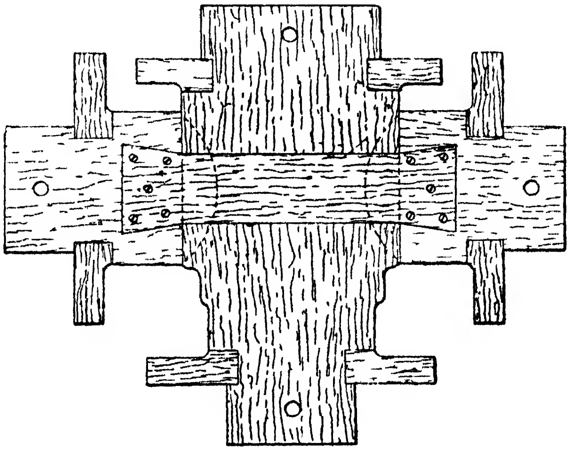


Fig. 58.

branches have to be fitted to a pattern body, the view being taken in the joint face of one-half of the pattern. A long

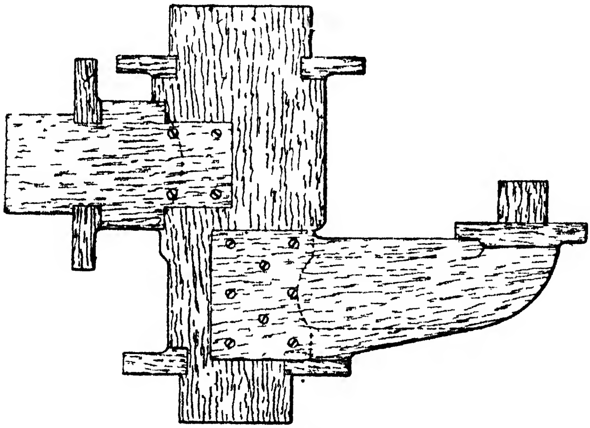


Fig. 59.

strip is let into the main portion having a dovetail at each end, which fits into the branches previously fitted r und the body, as indicated by the dotted lines. The four fla nges are

seen fitted into the recesses turned for their reception. Fig. 59 is an example in which the branches are shouldered down to

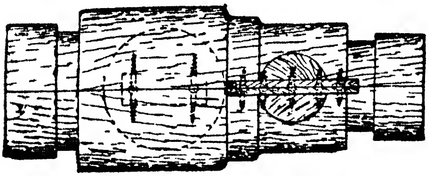


Fig. 60.

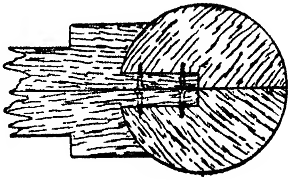


Fig. 61.

form halvings which are let into the main body as shown in sections in Figs. 60 and 61.

Fig. 61A.

Moulds in position on Magnetic Moulding Machines. An outstanding advantage is that they are self-contained, no attendant compressors or hydraulic equipment being necessary.

Courtesy, British Insulated Cables Ltd., Prescot.

CHAPTER III.

DETAILS OF PATTERN CONSTRUCTION.

Shop Drawings.—Tools.—Shrinkage—Timber.—Metal.—Cylindrical turning between Centres.—Face-plate Work.—Segmental Work—Gluing.—Dowels.—Rapping and lifting Plates.—Finishing of Patterns.—Allowances for turning and planing.—Name-plates.—Foundry Orders—Makeshifts.-Checking Patterns.

Shop Drawings.—In pattern-making there is considerable marking-out and scheming done both before and during the progress of the manual work. In some cases the first step is to make a full-size drawing of the required casting in as many views as may be necessary; in others this can be dispensed with. The pattern-maker is usually provided with a dimensioned drawing on a reduced scale from the drawing-office. This generally shows details of the finished article or mechanism, consisting of a number of different parts, and from it those which have to be castings are noted, and the pattern-maker considers how to proceed in making patterns for them. Those which are elaborate are sometimes redrawn full size by the pattern-maker before he can begin constructing them. A number of different views may be necessary, or one only may be sufficient, or some detail only may have to be drawn full size.

In other cases the work may be so simple that there is no need to draw it full size, but all the marking-out necessary can be done on the material itself. In very simple examples the shape can often be stated verbally, the dimensions given, and no drawing at all made. Thus a rectangular block or a plate, perhaps with a plain flange or rib, or a cylindrical article such as a bush, or a ball, or other simple shape, may be stated in words and its dimensions noted on paper. If the casting required is too complicated for this, a rough freehand sketch with dimensions is sometimes as serviceable and much more

quickly made than a scaled drawing. These last two methods are in use in the shops in dealing with isolated details, such as repairs, which are not designed in the drawing-office.

When a reduced scale drawing is provided, the pattern-maker does not, or should not, redraw anything full size unless there is some advantage in doing so. The necessity for a full-size drawing arises when the contour of the work is such that the positions of constructional joints and the exact dimensions of material for building up cannot be determined without such a drawing, and in other cases also where templets must be made and cannot be marked out satisfactorily unless there is first a complete drawing to verify their accuracy by.

The pattern-maker's full-size drawings are not made on paper, but direct on the wood surface of a drawing-board. A stock of these boards in a large range of sizes is kept in pattern shops, and new ones are made if wanted. They consist of pieces of board held edge to edge by battens screwed to the back. Old drawings are sometimes obliterated sufficiently by whitening the surface with chalk. Occasionally the surface is cleaned with a smoothing plane. A board is not considered unsuitable if it is not quite large enough to include one or more extending portions of a drawing, as a few inches can easily be added temporarily anywhere round the edges of a board. All except the smallest boards are placed on trestles for use in any convenient place near the bench, and if it is not too much in the way it is usual to keep a large board permanently thus, and utilise it for the building of patterns which would occupy too much room on the bench.

Lines are either scribed or pencilled, and a drawing is often a combination of both, lines where great exactness is required always being scribed. Usually the outlines of the casting are drawn, with allowance for shrinkage. Allowances for machining are often omitted, and prints are not drawn unless for convenience in getting the size of the core-boxes. Parts shown in section are shaded with diagonal pencil lines to make the drawing as clear as possible at a glance. As with scale drawings, it may be necessary to have more than one view, but full-size views are not made for the purpose of making the shape of the casting clear. The small-scale drawing will do that equally well. Full-size views, as already stated, are only made when they are a necessary aid in the construction of the pattern. The use of centre lines is important when portions

on each side of them have to be symmetrical, and centres from which radii are struck are clearly indicated. As the squareness of a board cannot always be relied on, the gauging and squaring of lines are often done from one edge only. A tee-square or large wooden try-square, sometimes in conjunction with a straightedge, may be used for squaring, or in large drawings it may be more accurate to use a straightedge only and measure from the edge of the board and from one line to another for parallelism.

The methods of moulding and construction are usually decided before the full-size views are made, and as soon as the latter are completed the pattern-maker can take measurements from them for getting out the pieces of wood for building the pattern. These measurements do not necessarily coincide with dimensions given on the small-scale drawing, for joints often occur at places which can only be properly determined on a full-size view. Fig. 62 is an example of this in segmental work, and other instances may be seen in subsequent illustrations. In Fig. 62, A shows two views of a chain pulley, and B shows a quarter-section of the same as drawn full size, the latter being all the pattern-maker requires for making it by. The shape of the rim in section is drawn, the necessary dimensions for it being given on the small-scale drawing, and then the pattern-maker can decide how many layers of segments will be wanted and fix suitable inner and outer radii for each layer, then saw them out and build up accordingly, and turn the rim to shape by templets cut to fit the contour on the drawing-board. Where diameters and depths can be measured with a rule or calipers, templets can often be simplified, and often, instead of including a complex contour in one templet, it may be sufficient to divide it into two or three separate ones cut to single radii only.

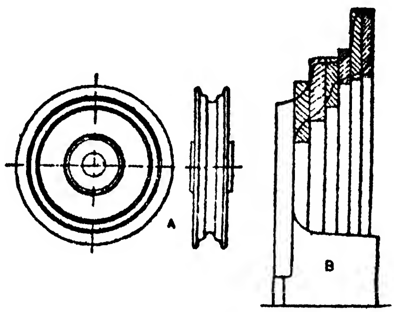


Fig. 62.

Fig. 63 is a section through a lathe bed. The pattern-maker would draw this full size, but a longitudinal elevation

and plan would be unnecessary. If the bed had a gap or was otherwise not uniform, it would probably be necessary to draw a portion of it longitudinally to assist in the building up. If, however, the bed was small and the gap shallow, the outline would be drawn direct on the pieces of board which form the sides of the bed. Fig. 63 is, of course, an instance where it would be usually sufficient to draw a half-view only, just as in Fig. 62 a quarter view is sufficient. Cases of this kind often occur, and the amount drawn is often settled by the size of the drawing and its complexity. If small and simple in outline there is no objection to including more than is absolutely necessary, and the work may be made clearer by doing so.

Fig. 64 is a bend pipe, for which a sectional view as shown is necessary, or at least highly desirable. Nothing less will do, and nothing more is wanted. If the length was too great for

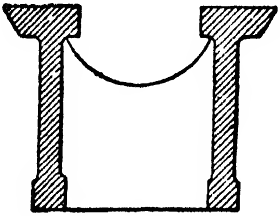


Fig 63.

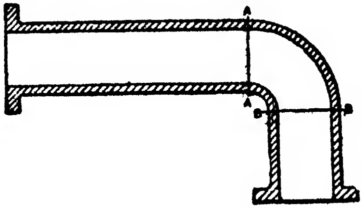


Fig. 64.

the board available, the drawing could be shown broken, as is often done in small-scale drawings, and the material for the pattern would be cut to the length required. The joints for the bend would be put on the drawing, and the bend and straight pieces made accordingly. If one of the straight pieces was short and the bend of small radius, one joint only would be made. In most cases there would be a radial joint at each end of the bend, as shown at A—A and B—B. In a large bend there would be one or more intermediate joints as well.

Fig. 65 is another instance where only a sectional view is necessary and where it is essential to have it. It shows two bevel-wheels, one built up, the other solid. The latter is turned to measurements and angles obtained from the drawing, and the lightened-out portion by templet. The larger wheel is marked out for segments on the drawing and turned by the same methods as the first, teeth in both cases being cut after the body is turned.

Fig. 66 shows section and plan of a circular cap with templets for turning it by. Here also the pattern-maker would draw only the section, the plan not being necessary, because its shape is understood, and a full-size view, though consisting only of a few circles, would not be worth putting on the board. By means of the full size, section joints for making the required depth can be fixed, and these in turn give the diameters of the smaller pieces. If no building-up is necessary, then the drawing still serves for making the inner and outer templets by, or at least it facilitates making them, and their depth to the shoulders can be checked by trying them on the drawing.

Tools.—The equipment required by a pattern-maker working in a modern shop is very limited compared with that essential in the very small shops. Consider the saving in time and the

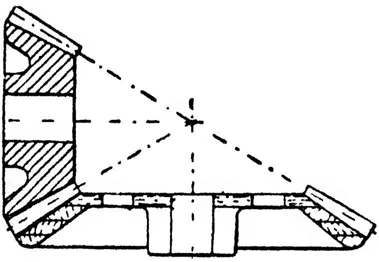


Fig. 65.

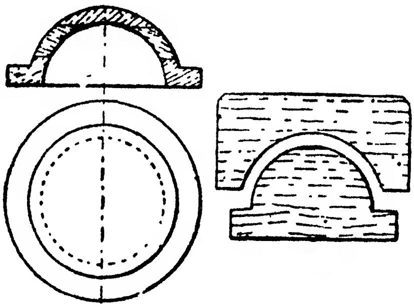


Fig. 66.

economy effected in tools by the use of the Universal Pattern Miller (Figs. 549 and 550).

A very comprehensive outfit for a pattern-maker might comprise the following items: hand-saw, tenon, dovetail, bow, compass, and keyhole saws; jack-plane, trying and smoothing planes; about eight round planes, ranging from Nos. 4 to 18; three rebate-planes of various widths; thumb-plane, bull-nose and compass planes; half-a-dozen paring chisels of various widths, ten or twelve paring-gouges of various widths and sweeps, half-a-dozen firmer-chisels from $\frac{1}{16}$th to $1\frac{1}{2}$ inches; two short marking-gauges and a panel-gauge, a brace and set of thirty-six bits, two pairs of trammels, large and small respectively, wing compasses and dividers, calipers (inside and outside); axe, turning-gouges and chisels, round nose and side tools (about three of each);

a 6-inch and a 12-inch trying-square, to which may be added a 20-inch or 24-inch one of wood; a bevel, sundry set squares, hammer, pincers, pliers, two spokeshaves, brad-punches, gimlets, bradawls, oilstone, gouge-slips, mallet, screw-drivers, large and small, scriber, a few files, scales, and a standard and contraction-rule.

Special mention must be made of this last tool, which is used only by pattern-makers. As its name implies, it is a rule which is made longer than the standard measure by the amount which cast iron contracts in cooling from the molten state to the ordinary temperature of the atmosphere. Though a standard rule is required for the measurement of castings, it would be obviously inconvenient to use it in pattern-making, because the workman would be perpetually making approximate allowances for contraction in fractional parts of a foot. So the contraction-rule economises his time and ensures something more accurate than approximations. A 2-feet contraction-rule is nearly $\frac{1}{4}$ inch longer than a common rule—strictly speaking, $\frac{1}{4}$ inch in 2 feet 6 inches. This represents nearly the maximum amount of shrinkage for iron, and is fairly correct for general work. But an experienced pattern-maker knows that he must not trust too much to his rule, but that special allowances are required for special classes of work, and for different qualities of metal as well as for different kinds of metal. Thus, while iron contracts $\frac{1}{8}$ inch in 15 inches, brass shrinks $\frac{1}{8}$ inch in 10 inches, steel $\frac{1}{4}$ inch in 12 inches. A heavy casting will contract less than a light one, while a small casting will often come out as large, or even larger than the pattern. Hard white iron will contract much more than soft grey iron, and the presence of large dried cores in the mould will diminish the amount of contraction. A plate with large superficies will almost invariably come out *thicker* than the pattern, owing to the fluid pressure exercised by the *head* of the runner, and also to the top-part box not being entirely rigid. Experience alone can guide in these matters; and some element of uncertainty will always be present, for different mixtures of metal will show different shrinkages, as also will rapid or steady lowering of the temperature in the cooling of castings. But in general, for castings of moderate size, the contraction-rule is practically correct. Few men provide themselves with a contraction-rule specially for gunmetal and brass. Rules are sometimes made having

the divisions for iron contraction upon one edge and those for brass upon the other. But one is apt to make blunders in measurement where this is the case, and the safer way is to have a rule giving contraction for iron only, and to make the additional allowance for gunmetal when necessary —very approximately one and a half times that of iron, or $\frac{1}{8}$ inch in 10 inches.

Timber.—The timber used for ordinary patterns is yellow pine. It is light, soft, easy to work, comparatively free from liability to warp and twist, and it is cheap. Red deal and pitch-pine are unsuitable, since in the foundry sand they absorb moisture, and become ridged and rough, causing the mould to tear up when the pattern is withdrawn. They are, besides, not so pleasant to work up as the yellow pine. For small patterns mahogany is an excellent wood, hard, strong, and not liable to warp. Its price precludes its use except for small patterns, or patterns which have to be moulded repeatedly. Other woods are occasionally used, but these are the best, and are the ones in commonest demand.

The selection of the most suitable materials to use for given patterns has to be settled by the numbers of moulds required off, and in some degree by the methods of moulding adopted. Specifically here we need only consider the question of wood *versus* metal.

Metal.— It is usually necessary to employ metal patterns when very large numbers of castings are required. Exceptions occur in the case of those of large dimensions, for which metal is undesirable, though quite practicable when proper lifting tackle is available. Large metal patterns can often be lightened so that they need not weigh very much in excess of wooden patterns. The same remark applies to core-box framings.

Metal is used for flimsy patterns, such as belt and rope pulleys, even though few castings are wanted, simply because the short grain present in wood is so liable to fracture. An exception occurs when such patterns are attached to wooden plates for plate moulding, and when they are fitted to special joint boards by which they are supported during jointing and ramming.

In all intricate and ornamental work of a flat character, such as gratings, panels, and scroll designs, metal must be used, the short grain of timber being far too weak to endure any ramming. The patterns may be made in plaster or lead, or sometimes in

wood, or in the case of regular designs may be first cored out and subsequently filed.

For nearly all small work of standard character it is desirable to use metal patterns, the alternative being mahogany. The same remark applies to small core-boxes. Machine-moulded work is, unless of large dimensions, properly made of metal. Risk of warping does not come in, nor does roughening up of grain interfere with a clean lift. Weight is not objectionable when turning over, and withdrawal is effected in a suitable machine.

The kind of metal to use generally depends on the size. Small patterns are mostly made of brass, as also are those of large dimensions when of slender design. Most others are of cast iron. Exceptions are white metal in small patterns and core-boxes, and lead for temporary and intermediate service—that is, if a piece of work includes curved portions which can be easily produced by bending, it is often made in lead, from which a permanent iron or brass pattern is cast. Each of these presents alternatives. In a large number of cases there is practically no choice, the best method being self-evident to a man with some experience. But many jobs lie on the border-line, and the determining factor is generally the numbers of castings required off.

Cylindrical Turning Between Centres.—A large proportion of the cylindrical work done between centres has to be in halves for convenience in moulding. Flanges and other parts to fit on this are often turned separately on the face-plate, and must be in halves also. Such work cannot be turned solid, and sawn through the middle and have its joint planed after, because the sawing and planing would reduce its diameter in one direction, and it would no longer be truly circular. But there is no difficulty in fitting the halves and turning them after. It only involves the adoption of some means of holding them together and taking care to centre them properly in the lathe. On the face-plate the halves are screwed in the ordinary way, each half separately with not less than two screws and with the joints exactly on the centre of the plate. Between centres, the halves must be well secured to each other before they are put in the lathe. This may be done with staples or dogs, as in Fig. 67, with screws, as in Fig. 68, or with centre plates screwed on the ends, as in Fig. 69. In large, heavy work, centre plates and staples are always used, and sometimes screws as

well. Staples are always used when the diameter is large, to keep the joint close at the edges and often they are used at intermediate points along the length, and are shifted from one place to another as the turning proceeds. In long work between centres, deeply sunk screws, as in Fig. 68, are used at intermediate points, and are of a suitable length and sunk sufficiently to clear the tools in turning. Intermediate holes

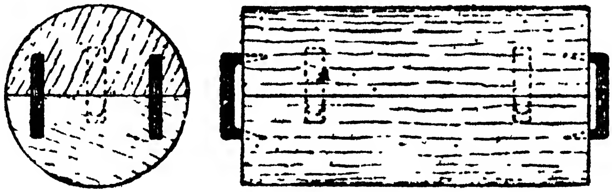


Fig. 67.

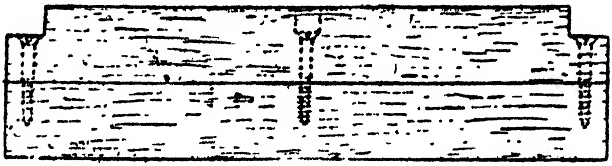


Fig. 68.

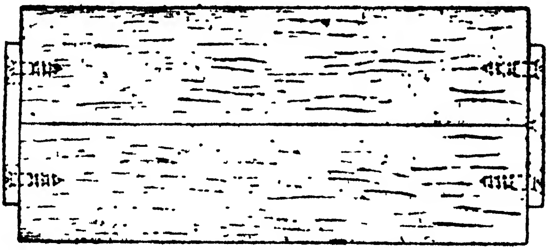


Fig. 69.

have to be plugged after, but screws at the ends come in the waste portions which are cut off after the article is turned. Notching down at the ends, as shown, is generally preferred to countersinking. Sometimes, in small diameters, neither is done, but the parts are simply screwed together with the screw heads flush, and care is taken not to turn down on them with the tools. Centre plates are used for heavy work, even when it is not in halves, because without them there is risk of the

work jumping out of centre, or even out of the lathe, owing to the softness of the wood and inability of the lathe centres to hold it securely and accurately. Metal centre plates screwed to the wood prevent this, and are an aid also in accurate centring at the commencement. For comparatively light work in halves, centre plates with prongs similar to staples, but shorter, are sometimes used instead of screwed-on plates, being more quickly attached. The ordinary centre plates are shown separately in Fig. 70. One plate is slotted for the fork centre and the other countersunk for the dead centre. These have to be set accurately on the joint, or the turned halves will be unequal. The surface on which the plates bear may have to be levelled with a chisel, owing to the halves in the rough not exactly corresponding in length or not being sawn perfectly square. This is done, if necessary, with the halves dowelled or stapled together.

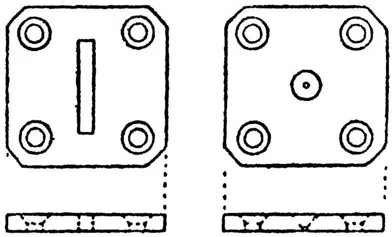


Fig. 70

Halves are generally dowelled, and this, of course, is always done before turning. The only exceptions where dowels are not used is in turning small portions in halves to be attached to the main pattern. Small flanges in halves are seldom dowelled, the dowels in the main body of the pattern being sufficient, and the same is true of very short branches or extensions or prints in halves on larger dowelled bodies, which themselves may or may not be turned. The finished size and shape of the work has to be considered in placing the dowels. As they play no part in holding the halves together this is done by the ordinary methods, regardless of whether the parts are dowelled or not. In Fig. 67 wood dowels are shown dotted. Metal dowels of various kinds are commonly used, and, of course, the dowelling of parts is as common in bench as in lathe work.

In some cases more than two articles have to be turned at once in a single length of stuff. Where boss sections fit on opposite sides of a web or plate, then a piece of wood of the exact thickness of the plate is fitted between the boss sections, as in Figs. 71, 72. The thickness piece is then thrown away,

and the boss sections used. Paper joints and screws are more useful in these cases than the plates, because they prevent any tendency of the surfaces to slip.

Fig. 71.

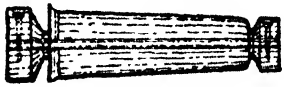


Fig. 72.

Face-plate Work.—This, both small and large, is handled in many ways. It is of a very different character in a brass-finisher's shop, and in that of a general engineer's, or a production shop. Two kinds of face chucks are used, the smallest with a tapered screw, and small, medium, and large sizes with screw holes only. Most pattern work is turned on intermediate face-plates of wood, for several reasons. All pieces of large diameter, and all articles which are rechucked, have to be so done, and most of those of small diameters are so turned.

The taper screw chuck (Fig. 73) is used in direct contact with the work, for small articles only, and these chiefly bosses which are turned plank-way of the grain. Pieces which have to be turned long-way of the grain in soft wood cannot be held securely on account of the screw stripping the wood. These must be put in the bell chuck. But the taper screw chuck is used frequently with a wooden face-plate intermediate between it and the piece to be turned. Much small work is thus dealt with, being held and done by the same methods which are adopted in that carried on larger face-plates, to be noted directly. The advantage of the taper screw chucks in this respect is that they are of small diameters, and it is often necessary to use chucks smaller than the work turned on them, as when the hinder part of a piece has to be got at, to avoid rechucking. The chuck is often provided with three holes for screws, which afford additional security in holding a wooden face-plate or a piece of work.

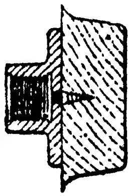


Fig. 73.

After this, the smallest of face-plates, come the plain ones (Fig. 74), made in brass or iron, which differ from each other only in size, of which every lathe has an equipment of three or four, smaller and larger. They are screwed directly to the

work (Fig. 75) or to an intermediate face-plate (Fig. 76). In the latter case the piece of work may be held with screws passing through both plate and chuck; or, if of large diameter, with screws that go through the wooden chuck only, beyond the diameter of the metal plate, as in Fig. 76. Or instead, screws may be put in from the front as in Fig. 77, or other methods of holding are adopted according to the character of the turning being done.

Quantities of thin bosses and circular facings are turned while held with a couple of loose nails only (Fig. 78) on a wooden face-plate. The nails stand out ½ inch or so, and are withdrawn readily by the pincers after turning. These bosses are frequently not faced, the board from which they are cut having been thicknessed first. Only the edge then has to be turned. If the stuff is not thicknessed first, nails may still be used and thicknessing be done close to the nails, as in Fig. 78, and the central part will be reduced with a plane after the bosses have been put in position on their pattern.

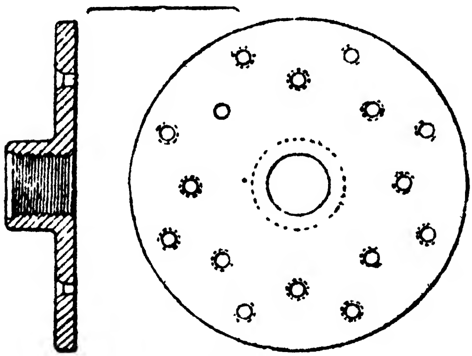


Fig. 74

Nails or screws are frequently used when turning rings. They are put in through the central disc left by the cutting-off of the ring. Thus a pump-ring like Fig. 79, typical of many others—turned in solid mahogany—would be held by nails as shown, or screws, or sometimes by a paper joint at the centre, and the ring when finished would be parted off with a chisel presented as in the figure. Valve seatings, if shallow, might be turned in the same way, or alternatively in the bell chuck.

In the selection of methods, much depends on the thickness and weight of the work. Very large pieces cannot be held securely with nails; then screws are put in either from back or front, whichever happens to be more convenient. Figs. 80 to 82 show three common jobs as alternatives. The illustrations are of two beadings and a flange. It is usual to prepare work of this kind on a face-plate ready to slip into grooves that

are turned in the body of a column or a pipe pattern. The column beading in Fig. 80 may be attached with screws in the central area to the face-plate, and be turned convex on the back

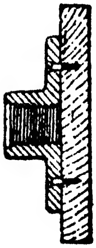


Fig. 75.

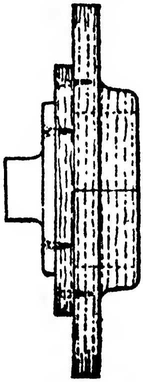


Fig. 76.

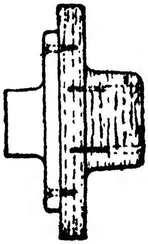


Fig. 77.

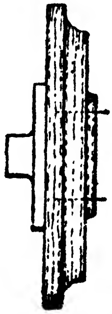


Fig. 78.

and front, and then parted off as indicated. The lathe is run slowly as the parting cut approaches completion, to prevent the beading from flying off, or it may be stopped and the last $\frac{1}{16}$ inch cut through with a saw. In Fig. 81 a flange is being

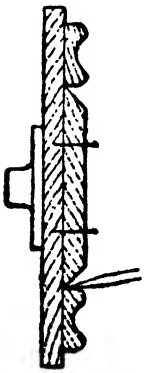


Fig. 79.

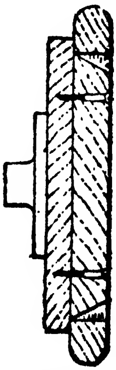


Fig. 80.

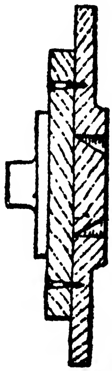


Fig. 81.

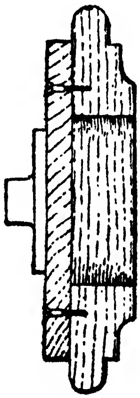


Fig. 82.

turned with a small hole. Screws are put through the wooden face-plate into the flange, and the central hole is bored out, leaving the flange attached to the plate. In Fig. 82 a column moulding is shown with the screws put through the wooden chuck from the back.

Segmental Work.—Complete rings are turned in a lathe, and building up proceeds on a face-plate. A considerable proportion of segmental work is not in complete circles, and is worked to shape by hand before or after each segment is fitted in place. In turned work the first step after the segments are sawn out is to get a suitable face-plate—that is, a plate large enough in diameter to take the work. It is faced true, and a pencil circle marked to set the first layer of segments to. The means of attachment to the plate has next to be considered. There are three methods in ordinary use — glue, nails, and screws. Glue is very frequently employed, supplemented by screws in heavy work. The segments are not glued directly to the wood of the plate, but to paper which is glued on the plate first. This holds the work as securely as gluing wood to wood, and when the turning is done the work can be prised off with a chisel without injury to its own surface or that of the plate, for paper splits and half its thickness still remains glued to each surface. This method is secure enough for all ordinary work ; in fact, if paper was used all over the surfaces to be united, it would give too much trouble in prising the work off the plate. Therefore a patch of paper is used under each of the end joints as seen in Fig. 83. If any doubt is felt about the security of this, screws are put into the work from the back of the plate after two or three layers have been built up. If it is desired to proceed without glue, and so avoid waiting for it to dry, the first layer may be screwed to the plate from the back. Wire nails are sometimes used instead of screws when the work is not very heavy. It is more convenient to put these through the layer of segments into the plate, just the reverse way to screws, as shown in Fig. 84. The nail heads are covered by the next layer of segments, but as the work has to be prised off the plate this does not matter. The projecting points can afterwards be hammered down. The screws are preferable.

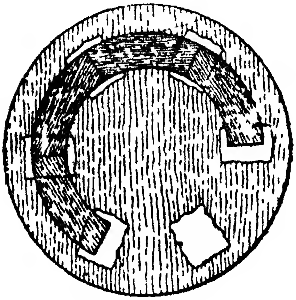


Fig. 83.

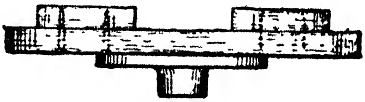


Fig. 84.

In fitting a row or layer of segments, or strictly sectors, one face of each is planed true, and (except when it is in the first layer and merely goes on the plate surface) it is tried in place, and care taken to make a close joint. The fitting of the ends is usually done by cutting them on a trimmer. The old way was to plane them on a shooting board. The shooting board is still used when a trimmer is not close at hand. The trimmer is not quite so accurate, but the end joints of segments are less important and less noticeable than the layer joints. The advantage of a trimmer is that a large amount can be cut quickly without having to use a chisel or tenon saw. It is not necessary to mark radial lines on the plate, or pay any attention to lines on the sector pieces. The ends are simply cut approximately radial, and each succeeding segment is fitted to suit the end of the one previously attached, regardless of strict geometrical accuracy in angle or in length of segment. Often the last sector in a layer has to be cut $\frac{1}{2}$ inch or so shorter to suit the space left for it to fill. After each layer is put on, its upper surface is faced true in the lathe, and it is necessary at the same time to see that thicknesses are kept approximately correct, otherwise a cumulative increase on a number of layers may necessitate turning the last layer undesirably thin. Occasionally there are reasons why the work cannot be put in the lathe for truing each layer, and then it is planed by hand true enough for fitting the next. In building up considerable depths the inner and outer diameters are also roughly turned at intervals and measured to ensure accuracy in setting layers which follow, otherwise it may be found when the building-up is completed that the work will not hold up to diameter in places, while in others a lot of material has to be turned off.

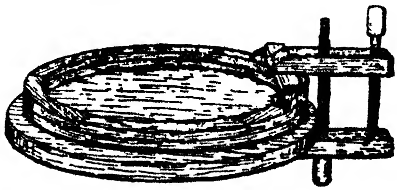


Fig. 85.

Sectors that are united with glue alone should be clamped as in Fig. 85, one at a time as they are put on, and the clamps remain for half an hour or more until the glue is set sufficiently for turning. If clamps are not used, the joints do not hold so well or look so close when the work is finished. Some men use staples to pull the end joints tightly together before putting a clamp on the segment. Sometimes a clamp is put on, and

then the segment is nailed and the clamp can be taken off immediately. The use of a clamp in such cases is to prevent the glue joint from being disturbed by the shock of hammering. The use of nails is often objected to, especially in work of narrow section, because nails are liable to run to one side, and in turning may damage the edges of the tools. In plenty of cases, however, nails may be used quite safely, though in the best work the use of glue alone with first-class joints is generally preferred, and sufficient time is allowed for it to dry before turning. Or wooden pegs are driven in.

Work is turned to shape by measurement, assisted when necessary by templets. Rechucking is occasionally necessary. It is done by turning the face-plate to fit some convenient portion of the finished side of the work and holding the latter to the plate by means of screws. Sometimes, to avoid recessing a large plate, blocks are screwed on it and turned to fit the work. Often a central stud hole in the pattern is used for chucking it by. In rings an outer or an inner diameter, or both, must fit a shoulder of similar diameter on the face-plate. This plays no part at all in holding the work to the plate, but centres it accurately for screwing.

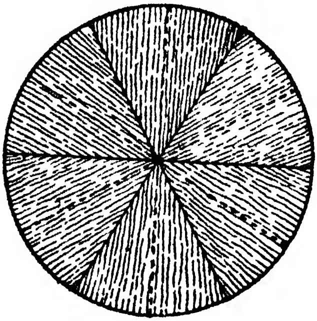


Fig. 86.

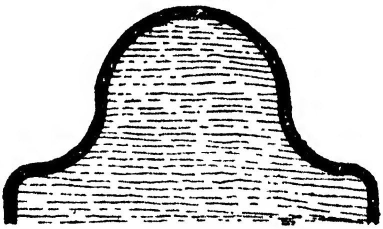


Fig. 87.

Fig. 86 shows a form of segment used in making solid circular plates for wheel centres or other purposes. It consists of two or more layers. It is not really very strong alone, but is strong enough when stiffened by sectors round the edge on one or both faces. Its advantage is that it always remains a true circle, the slight amount of shrinkage that is possible in the segments having no effect on the diameter, for it has uniform end grain all round the outside.

Fig. 87 is another common example of segmental work. A plate of variable contour has to be stiffened by a shallow

rib round its edges. This is done with a single layer of sector pieces varying in length and curve to suit the shape of the plate. These in this case would be planed to thickness and finished with chisel, gouge, and spokeshave before being finally screwed on. A slight amount of further dressing might be necessary after, but only to make edges perfectly flush.

Gluing.—The art of gluing consists, first, in making as perfect a joint as possible in readiness for the glue. The best glue will fail to hold if the joint is badly made, because it will lie thick and thin in different places, and a thick stratum has little holding power, being weak in itself, and more readily affected by atmospheric conditions than a thin one. The thinner, therefore, the stratum of glue, the better. Its efficiency is due to the inherent strength of its cementing quality, and to its penetration into the grain of the wood. Hence the reason of the practice of rubbing joints, both to work the glue into the grain, and to get rid of all that is superfluous.

With few exceptions, no attempt is made to unite surfaces on which end grain is exposed. The reason is that end grain absorbs all the glue, leaving none on the surface to secure attachment. The only way in this case, when no alternative exists, is to warm the stuff, and thoroughly saturate the ends with glue, until the open grain ceases to absorb any more, as evidenced by the glue lying on the surface. Let it remain thus for some little time, and then brush over again and attach the pieces; but such a joint can never be thoroughly relied on, unless it is reinforced by some other means, as dowels, nails, screws, etc. The same applies, though in a lesser degree, to joints made between surfaces in which the grain is cut in a diagonal direction. These require to be thoroughly saturated, and are seldom reliable.

The only way in which a perfect joint can be made is between faces which lie parallel or nearly so with the longitudinal direction of the fibres. The method of procedure is as follows: —Make one face of the two pieces to be united true first, and then fit the second to this. If both faces are planed alternately and at random, a good joint cannot be secured. Two general cases occur—that of an edge and of a face. For the first a straightedge or square must be used to get the primary edge true. This is then chalked over, and the second edge fitted by noting the transference of the chalk from No. 1 to No. 2. In the second case the first face is trued by the aid of winding

strips and straightedge, and the second is fitted to it by planing, noting the transference of the chalk.

It is better to have a joint close around the margins, and slightly hollow about the central portions, than that the opposite conditions should exist. Slightly concave faces do not hold well. Moreover, the act of gluing tends to render the faces of the thinner pieces of wood convex, another advantage of imparting some slight concavity to joint faces.

To glue the joints well, the shop must be warm. Good joints cannot be made in a cold atmosphere, because the glue will become chilled, and fail to hold, remaining permanently damp and useless. In gluing stuff of average dimensions, no further precaution is necessary; but in very thin board and in veneers, on which the glue is liable to become chilled before the jointing can be completed, it is usual to warm it either before a fire or, better still, by means of water from the glue-pot. The latter procedure is also adopted to prevent the moisture of the glue from curling thin wood into a convex shape, and so spoiling the joint.

When gluing surfaces, they must be rubbed over one another, to effect a perfect union. The general plan is to fix the bottom piece, either in the vice or to the bench, by a bench-knife or dogs, or other means, and rub the upper piece over it. The glue should be brushed over both surfaces, to give it a little time to penetrate the grain. The two are then rubbed and pressed together, the motion of the top piece partaking of a to-and-fro longitudinal movement, combined or not with a twisting motion. For small work the two hands of one person are sufficient to do the rubbing, but for long pieces, whether faces or edges, the assistance of another is necessary, holding the stuff at each end, who work in unison, and stop rubbing at the same instant. The time to cease is that at which the surfaces are found to cling very tenaciously, which corresponds with the rubbing out of the greater part of the glue. If glue is poor or watery, a joint will never hold permanently, however truly it is planed, neither will a thicker stratum of glue help it. All glue must be thin, but if new and strong it will hold perfectly, while thick, poor glue will not.

Joints of considerable width in thin boards must be made with some mechanical aid. It is usual to hold or tack a strip behind one of the pieces to keep both true. Or the joint is made with the boards lying flatwise on battens.

Good and permanent joints cannot be made unless the stuff is perfectly seasoned. If the wood tries to shrink, glue will not prevent it. Either the joint will break, or, if the glue holds, the wood will split.

After a joint is made it will become spoiled if during the drying the timber warps under the action of the moisture. In thick stuff, and in gluing the edges of wide boards there is little risk of this. But all thin pieces have to be coerced during the period of the drying of the glue, for which purpose it is usual to employ clamps of wood or iron, or weights.

Dowels.—These are in constant request in the pattern shop. But the dowels of the pattern-maker are used with quite a different purpose from those of the cabinet-maker and carpenter. The latter must hold tightly in the wood; the former simply act as steadies to pieces which have to be left loose in moulding. The purpose of the two being quite distinct, their forms differ also. The cabinet-maker's dowel is a parallel pin fitting tightly and glued firmly into each of the two pieces which are jointed together. The pattern-maker's dowel, on the contrary, fits tightly into one piece only, the other being left so easy a fit that the loose piece will come away with the top sand from the lower part of the pattern. But this does not mean "slop," for too slack a fit would cause overlapping joints and inaccurate work. The fit should be good when the joints are closed up, and only slop when they are separated. Hence the dowel is parallel through one-half only of its length, and tapered like a print through the other half, the first portion being that which is driven home, the second that which retains the temporary loose piece in position.

Formerly, all dowels were made of wood in the pattern-shop —oak, apple-tree, birch—almost any hard wood was used. They were laboriously turned in the lathe, or even planed on an angle-board, then cut to length as required, to be finally finished with a file. To-day they are replaced by metal dowels purchased in any desired size and length, from firms specialising in pattern-makers' sundries. These are vastly superior to the wooden ones, being more accurate, less likely to become broken off or damaged, and consequently more durable. Two forms are shown (Figs. 88, 89), each of which is made in various sizes. The peg and cup dowels (Fig. 90) are made in brass, and are quickly

fixed; but the plate dowels are more suitable for permanent work.

The brass dowels are put in thus. Say we have two pieces of wood prepared for a plain round core-box (Fig. 91). Square over from their two correspondingly true edges, two corresponding lines representing the centres of the dowels,

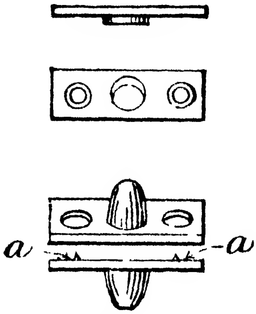


Fig. 88.

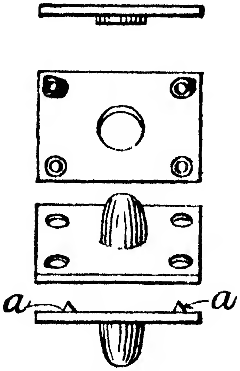


Fig. 89.

Fig. 90.

measured longitudinally. On those lines gauge at equal distances from the edges other lines, the intersections of which will be the centres of the dowels. But we do not always want the trouble of squaring edges, neither in all cases is it possible to get a square edge to work from. So a true way and ready is to lay a common pin in the joint with its head covering the

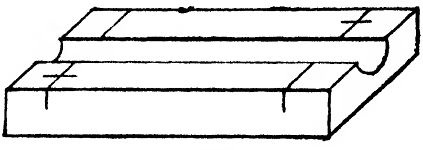


Fig. 91.

spot where we want the centre of the dowel to come, and then to press the upper and lower blocks together. The pin-head will leave its impression on the two blocks, corresponding exactly with one another in position, and these form the centres for running in the centre-bit. Half a dozen or any number of holes may be marked thus if needed, and all perfectly true. This is so good and simple a method as to be preferable to the scribing of lines.

Having the centres marked, bore holes, so that both shank and cup may be driven in tightly. Note that the portion which is driven into the wood is not screwed, as it may appear to be at first sight, but is simply grooved out concentrically. The idea is, that the yielding grain of the wood being forcibly driven out of its natural position by the blow, will afterwards swell out and hold the dowels in position by filling up the inter-ring spaces.

The plate dowels are put in thus. On the underside of the female plate there is a ring (see figures). In the joint of one of the pieces of stuff to be dowelled bore a centre-bit hole, into which this ring shall fit tightly, the hole having a depth slightly greater than the length of the dowel-pin itself. Dropping the ring into this hole, scribe round the edges of the plate, remove it, and cut a recess to that size, and equal to the thickness of the plate. Drive in the plate, see that it is flush with the surface of the joint, or, even better, just a shade under it, and screw in place. Then the male plate is dropped in, the top half of the pattern lowered over it steadily into required position and pressed downwards. The two points or nibs, *a*, *a*, which stand out from the back, will then leave an impression in the top of the pattern, by which we can, when turned over, set the plate in that half and mark its exact boundaries. Its recess will then be cut, into which it will be screwed, and if done carefully no fudging will be necessary to insure a proper fit between pin and hole.

Rapping and Lifting Plates.—Rapping and lifting are both essential to the proper delivery of patterns. The object of rapping is the loosening of a pattern from the contiguous sand, both immediately before withdrawal and also frequently during the period of withdrawal. In the smallest patterns a spike is simply driven into the wood, and being lightly struck two or three times with a small hammer, or a bit of iron rod, the pattern is lifted by it at once. But in work of considerable size and weight, a large pointed rapping or loosening bar of $\frac{1}{2}$ inch, $\frac{3}{4}$ inch, or 1 inch diameter is entered into a hole bored for its reception, and struck smartly with a hand hammer or a sledge on opposite sides in succession, until a perceptible amount of clearance, say from $\frac{1}{64}$ inch to $\frac{1}{32}$ inch, is made between the pattern edges and the sand. The larger and deeper the pattern the greater is the amount of rapping required, and the operation will need to be repeated over several different portions of the

pattern area. The lifting is then done with screws, which may be either twisted into the wood of the pattern or else ordinary standard threads, fitting into corresponding tapped holes in lifting plates attached to the pattern face, are used. Rapping and lifting holes are properly combined in the same plate.

In drawing large and heavy patterns where several lifting screws are employed, there are two methods of withdrawal, one being that in which several men lift at once, a man pulling at each screw; the other is done by hooking on the crane and hoisting slowly. In the first case, though there is no particular difficulty experienced in drawing deep patterns, yet in shallow ones, as gear wheels, for example, and when of rather large diameter, there is some trouble experienced in making a level lift—that is, in withdrawing the pattern in precisely the same degree all round. Want of parallelism in the act of drawing causes the sand edges to be torn up, so damaging the mould. When lifting a pattern in this way a man standing near is able to indicate to each one at the lift precisely how to work, whether to draw more slowly or quickly, so that all portions shall be as nearly as possible at the same level. At the time of drawing, either the men actually engaged in lifting, or others, if the pattern happens to be heavy or awkward, continually rap it lightly with wooden mallets, in order to detach it from the sand, which would otherwise cling to it.


Fig. 92.

When a pattern is very heavy, three or four sling chains are hooked on, and the lifting is done by the crane. The swivels in the chain (Fig. 92) afford the means of bringing up the separate chains to the same tension, so that the pattern shall lift perfectly level. By slightly straining up with the crane the men can see at once whether all the chains act alike. Those which may happen to be slack are then tightened by means of their swivels; at the same time the racking gear is used to set the crane hook perpendicularly over the work. As the crane hoists, the rapping is continued directly on the face of the pattern, wooden mallets being used in order to reduce the damage inflicted to a minimum.

Thanks to the cheap and efficient rapping and lifting plates now sold for foundry use, there is no excuse for omitting to make proper provision in standard patterns for these very

essential operations. These plates are made in malleable cast iron in many sizes, both broad and narrow, to suit different classes of work (Fig. 93). The larger sizes are provided with bosses, one for the rapping and one for the lifting hole, by which provision their durability is increased, and which bosses, being sunk into holes bored in the wood, also help to steady the plates under the rough rapping to which they are subject. The narrow plates are put into the edges of the rims of wheels, pulleys, flanges, ribs, etc., and the broad plates on the broad surfaces of patterns.

The general design of rapping and lifting plates is shown in Fig. 93, being a large and broad plate with holes for rapping and lifting. On this the changes are rung in dimensions and proportions, square, but more oblong, and with or without the deeper bosses. Such plates are sunk into the wood with

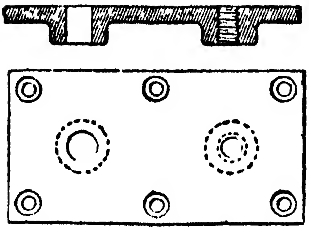


Fig 93.

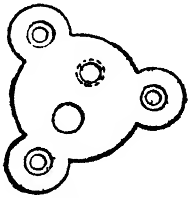


Fig. 94.

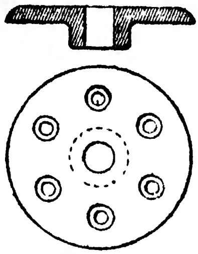


Fig. 95.

chisel and mallet and router plane, or old woman's tooth. An American style of plate is shown in Fig. 94, the advantage of which is that it can be fitted by drilling centre-bit holes.

Fig. 95 shows a circular rapping plate suitable for the backs of wheel bosses, the small boss answering the useful purpose of keeping the plate steady during rapping. There may be from three to half a dozen screw holes in the circle. Such plates stand up from the face, and are generally cast on to form shallow facings. The lifting plates are then let into the arms and rim. Fig. 96 shows the lifting screw used with metal plates like those in Figs. 93 and 94. Frequently the flange on it is omitted, and the taper of the screw alone ensures a snug fit in plates which have worn slightly large in the tapped holes.

The following points are to be borne in mind in putting in rapping and lifting plates :—(1) Never insert small plates when

there is room for those of larger size. (2) Secure them with the longest screws, in proportion to the sizes of the plates, that can be used. (3) When the stuff is so thin that room cannot be found for long screws, adopt special modes of fastening. (4) Never put in plates in such a way that there shall be any risk of their becoming torn out from the wood during the withdrawal of the pattern; this being really a summary of the foregoing. We put in the longest plates available because they have more bearing surface, a larger number of screw holes, and are less liable to become pinched out by rough usage than smaller ones. Long screws are used because of their greater holding power. But when a pattern required for standard use is of moderate thickness only, it is best not to put in the stoutest screws which the plate holes will take at first, but to use screws of medium, or rather small, size at the beginning, and as these become slack take them out and substitute screws two or three sizes larger, these again to be afterwards replaced with others bigger still.

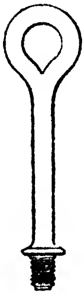
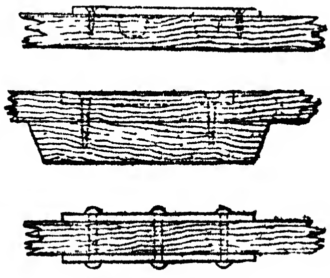


Fig. 96.

In very thin wood, two or three alternative plans may be followed. First, to obtain the maximum of hold for the screws, the plates are very commonly put upon the pattern face (Fig. 97) instead of letting them in, sinking the bosses alone, if present, into the wood. This affords a little more thickness available for screws, and only entails the filling in of the impression of the plate in the mould. When the security thus obtained is still not sufficient, the plate may be sunk in level in the usual manner, and a block of wood (Fig. 98), a little longer and wider than the plate, attached to the side opposite, the screws passing through both plates and pattern thickness into it. This also is an excellent plan, and only entails the stopping up of the impression of the block in the bottom of the mould. Another plan, which is suitable in those cases where even the filling up of this impression would be objectionable, as in some repetitive work, is to place two plates opposed



Figs 97, 98, and 99.

to one another upon opposite faces of the stuff, either sinking them in flush or letting them rest on the surface, and riveting the two together through the wood (Fig. 99); or countersunk machine screws may be used for the purpose of fastening instead of riveting.

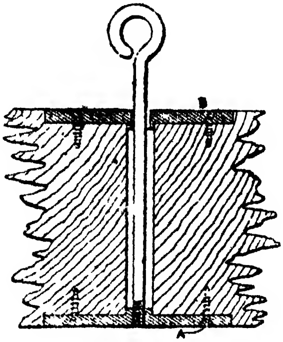


Fig. 100.

There are many patterns which are deep and very heavy. Great depth and large surface areas produce much friction during withdrawal. I have occasionally seen deep patterns, when not properly strengthened, separate in the mould in the act of withdrawal, the upper portions being torn away from those beneath. We need not be surprised, therefore, that lifting plates sometimes become torn out bodily. Taking a heavy pattern having a central boss, and lifted by the attachment of the crane hook to the boss, there would be perhaps a load, including friction, of a ton or more pulling against the screws in the lifting plate. But by adopting the plan shown in Fig. 100, where the actual lifting plate A is screwed upon the *bottom* side of the boss, and a rapping plate B on the top, with a central hole bored through the boss for the lifting screw, there is no risk of the plate giving way.

Fig. 101.

In patterns having deep and thin sides, where plates cannot be utilised, and which, owing to their depth, cannot be safely lifted with plates let into the top edges, straps of hoop or bar iron (Fig. 101) are employed. These, if properly screwed, cannot be pulled away; they both keep the stuff from going concave and from becoming torn asunder by the excessive friction set up by the withdrawal. These are also lifted by means of the crane and swivel chain.

When putting in rapping and lifting plates, regard must be had to the positions most suitable for their attachment. A moulder, in the absence of a plate, will often drive his spike into the shortest grain, and wonder that the wood splits. The pattern-maker should put plates in where the grain is strong and the plates not liable to dislodgment, and as far back from weak edges as circumstances will allow. When the wood

is thin, but stiffened with ribs, put the plates in over the ribs, running the screws right down into them. Or, if there are bosses or blocks present, try to get the plates over, and the screws into these. Also put the plates where the pattern will approximately balance—that is, in the centre of gravity. For if a pattern draws lop-sided, a bad lift is the consequence. The "hang" of a pattern can always be found by screwing in gimlets tentatively, and lifting thereby, until the proper positions for correct balance are found, when the plates will be put in accordingly.

Moulders are apt to excuse bad usage on the ground that no plates have been put on the patterns, or that they are located in unsuitable positions. Never give a moulder the chance of this plea in standard work, and it is a pity, when plates are so cheap, to allow patterns to be damaged through their omission.

Finishing of Patterns.—Patterns for the foundry may be left very rough, or a high degree of finish, almost equal to a French-polished surface, may be imparted. The difference which this makes in their cost is considerable with large patterns, but does not amount to much when they are small. A pattern from which only one rough casting is required, such as a foundry moulding-box or a special casting for temporary use, goes to the foundry unvarnished and unglasspapered, but with plenty of draught or taper for moulding. Large patterns for loam moulds are often simply oiled to prevent adhesion of the loam, and the wood is not otherwise protected nor the toolmarks glasspapered out. But in work with any pretension to neatness, and especially when a number of castings are required from the pattern and the latter is to be stored for future use, it is more carefully finished, often more substantially constructed, and receives three or four coats of varnish.

Shellac varnish is used for patterns. It is made by dissolving shellac in methylated spirit. This takes several hours to accomplish, with occasional stirrings, and the vessel it is done in must be covered to keep the spirit from evaporating. When it is applied to the wood the spirit soon dries and leaves a coat of hard glossy shellac on the surface. This prevents moisture from entering the pores and swelling and warping the wood, and also makes a smooth surface for withdrawal from the mould. It is a great advantage in both of these respects, and without it the bare wood would soon get very dirty in the foundry.

If a pattern is worth varnishing at all it should have at least two coats. The first coat sinks into the wood and leaves no gloss on the surface. The varnish may be made thick in consistency, containing a large proportion of shellac to a small amount of spirit, or it may be thin with excess of spirit. In the first case fewer coats are required. In the second, more. In the first case the work will have a smeared appearance, brush marks being visible In the second more coats, and consequently more time and spirit will be consumed. The second case gives the most perfect results, especially on large surfaces where the varnish dries on one part before the adjoining surface can be coated, and so more or less overlapping of brush marks is noticeable. This, however, is only during the first one or two coats. The later coats do not dry so quickly, and the accumulating film of shellac becomes uniform in depth of colour. Shellac is orange colour, and so transparent that the grain of the wood always shows distinctly through it, no matter how many coats of varnish are applied. Sometimes other colouring matter, such as red lead or lamp black, is added to the varnish to help to fill the pores of the wood, and this gives an opaque coating like paint.

Before applying the first coat of varnish the pattern is glasspapered all over to remove toolmarks. A flat surface that has been planed is not perfectly flat, but shows a series of shallow waves caused by the necessary convexity of the cutter of the plane. These have to be levelled by glasspapering, which is done with a piece of glasspaper wrapped on a block of wood or cork called a rubber. Concave surfaces require a cylindrical rubber, or a rubber with one face shaped to fit the curve. Glasspaper is not often used without being put on a rubber. On rounded angles the flat rubber is used to remove chisel or plane marks, the glasspaper being worked round the curve, not along it. It is a general rule that the glasspaper must work transversely to the direction of the toolmarks. This is important only in the first glasspapering. Glasspapering is repeated after each coat of varnish, but its purpose then is to smooth the surface, which feels rough after the varnish has dried. The rubber is still used, but its movements then are generally in the direction of the grain, so that scratches will be less noticeable. As more coats are added the surface does not roughen so much as it dries, and after a third or fourth coat it is not necessary to use glasspaper. No matter

how many coats are given, however, the pattern is always glasspapered all over before the application of another coat. Glasspaper of finer grade, or worn glasspaper, is used for the later rubbings down, and the process is quicker than at first.

Screw and nail holes are filled level with the surface to facilitate moulding, not for appearance, as in cabinet-work and joinery. Putty is generally used for this purpose, but plaster-of-Paris or a mixture of powdered chalk and varnish is sometimes preferred, because it sets hard in a few minutes. Sometimes screws are countersunk and the holes plugged with wood. Melted shellac makes a good stopping, especially for making bad or broken places good, for it adheres well. Shellac is the main constituent of the prepared coloured stoppings used by cabinetmakers, but in pattern-making it is not necessary to use a stopping that matches the colour of the wood. The stopping of holes is generally done after the first coat of varnish —either then or before it. Glasspapering leaves considerable dust on the pattern, and this is brushed off and blown out of the corners before beginning to varnish. A coat of varnish dries in ten or fifteen minutes, but the best results are obtained when the pattern can be left for two or three hours or more before glasspapering down after a coat. By that time it has got perfectly dry, and all the roughness caused by the rising of the wetted grain can be rubbed off more perfectly than is possible when there is any dampness present.

Allowances for Turning and Planing. — The usual practice is to allow $\frac{1}{8}$ inch on iron castings for machining. This allows of two cuts being taken in the lathe or on the planing machine—a coarse first cut and a fine one for finishing. For brass castings one-half only of this allowance is given, $\frac{1}{16}$ inch. But this, though a general rule, is by no means to be universally observed. In a long casting, where there is a probability that it will not remain straight in cooling, more than the $\frac{1}{8}$ inch must be allowed, the precise quantity being regulated by the risk and uncertainty present as to the amount by which it is likely to buckle. In some long, disproportioned castings, the allowance may be as much as $\frac{3}{8}$ inch. Again, in a small engine cylinder, $\frac{1}{4}$ inch in the diameter is ample, but in a cylinder of 6 feet or 7 feet in diameter that would not be enough for safety, owing to the possible inaccuracy of the core and the uncertainty about contraction, and we should allow from $\frac{3}{8}$ inch to $\frac{1}{2}$ inch in diameter.

Then, on the other hand, a small piece of work need not have so much as the usual allowance, because, the surface being small, will only be affected by its local roughness and slight inequalities, instead of by some other portion of the surface two or three feet distant being possibly not in the same plane with itself. Neither is a small casting affected by contraction as a large one is; practically, it does not contract at all, since the rapping counteracts or more than counteracts its small amount.

Again, in set work—that is, work which is repeated over and over again without any variation—we get to know the amount of contraction so exactly, and the least allowance necessary for fitting so perfectly, that we can do with less allowance than it would be safe to allow for in a first casting. We then reduce it to the minimum, so that expense may be lessened in the turning and fitting shops.

Name-plates.—These are attached to all work leaving the shops. They are cast in iron or in brass. The letters put upon the pattern are first cast in lead or tin, what are called "block letters" being preferable, because easier to prepare, and not difficult to mend up if they tear the mould. They have a large amount of taper on their edges, and are fastened upon a wooden plate, which is usually surrounded with a narrow fillet-strip to improve its appearance. The letters are cast from metal patterns purchased for that purpose, and sold in many different sizes. The pattern-maker, in that case, has to file them up smoothly for moulding. Or they may be purchased by the gross already filed and ready for use. Common shellac varnish, especially if thickened with a little powdered chalk, will hold them very firmly; but, if for permanent use, small upholsterer's gimp pins, or pins still smaller but of the same shape, sold for the purpose by the letter-makers, will render them more secure. Larger lead letters, however, say from 2 inches upwards, will be screwed on the plate.

If a name-plate has to fit a curved or crooked casting it will be made straight in wood first, then cast in lead and bent to shape, and the mould made from the lead pattern. It will be as well to make a bottom board of the same shape to support the lead pattern during the ramming up. Or the pattern will be made straight, cast in yellow metal or soft brass, and bent then to the curve direct. Sometimes the maker's name, instead of being bolted to, is cast in a piece

with the work, the letters being put upon the pattern if cast in a vertical position. But if on the side where they would not deliver, the name-plate is put into a core-box, and the core dropped into a print impression made for its reception.

Foundry Orders.—We have referred several times to the upper and lower parts in moulding as affecting planed and turned metal faces. The moulder, in most cases, would not be able to distinguish the one from the other in classes of work to which he was unaccustomed. Hence it is the custom in some shops to indicate the faced and unfaced portions by distinctive colours. Thus, if the pattern were varnished with yellow shellac varnish, the portions faced might be coloured black or red. This practice is often extended to distinguish prints from bosses, which are sometimes confounded by the moulder, cores being put into bosses, and prints being cast on. Then a third colour would be adopted for all prints.

Further, to prevent mistakes, and to keep a pattern register on the pattern itself, a printed label is sometimes stuck on, containing sundry items—as for instance, "Pattern number, *A* 840; Number off, *Two; Cast, this side down.* Name of pattern, *Steam-chest.* For, 12-*horse engine*," and perhaps the initials of the foreman are added. Or a kind of cheque-book is kept by the foreman, and a written order from that book given loosely with the pattern to the foreman moulder, the counterfoil being kept in the pattern-shop. This might contain, "*date, order number, number off, name of pattern.*" In shops where little system is observed, because a very limited amount of work is done, it is usually considered sufficient to *chalk* on the pattern 1 *off*, 4 *off*, 12 *off*, as the case may be, and to give special instruction by word of mouth.

Makeshifts.—Work of a makeshift character often has to be done in the pattern-shop and foundry. Castings are frequently renewed without a wood pattern, the broken or worn casting, as the case may be, being made to do duty as a pattern. Where this is the case, all dirt and grease (which would cause the sand to stick) is burnt off; parts that would not mould by reason of their being undercut are filled in with prints, and core-boxes made to take out the undercut portions. Holes are filled up and printed; contraction, if the casting be large, is allowed for by thin strips of wood laid against the ends. Allowances for turning and planing are made by thin slips of wood, or of lead if the surfaces where the allowances are

required happen to be curved. Broken wheels are often replaced in this manner, new patterns being expensive. The broken teeth are made good by the pattern-maker, the wood being fastened to the metal with thick shellac varnish, and a couple of mending-up teeth provided to make good any falling down of the mould. These broken castings require varnishing in order to draw from the sand.

Thin sheet lead is very useful in the pattern-shop for lining up the patterns of brasses or other bearing parts in order to accommodate them for a smaller bore, for thickening up curved faces where it would be difficult or impossible to bend wood, or for increasing by a slight amount the diameter of a pattern—as, for instance, that of a flange or small rigger. The lead is fastened on with fine screws or with brads. For lesser increments of thickness limp cardboard or thick brown paper are serviceable, attached either with glue or shellac varnish. Plaster of Paris, too, is almost indispensable in the shop. In small work of a temporary character a pattern, or some portions of a pattern, or an alteration to an existing pattern, can be made in a few minutes with plaster, which alteration would take a very much longer time if done in wood. And since its purpose is but temporary, it is of no consequence if the plaster becomes broken on leaving the mould.

There is a good deal of rough work, as well as some of the very best, done in the pattern-shop. As a rule, the men who do the one class are not employed to any great extent upon the other. Among the rougher class of work shop tools take an important place, and in a large factory there is always sufficient in this line to keep one man constantly employed. There are boxes and turn-over boards for the foundry, special chucks and templets and setting blocks for the turners and fitters, bending blocks for the boiler-makers, and dies of all descriptions for the smiths. Much special knowledge is required in this work—little "tips" and "wrinkles," as the workmen say—and certain allowances, all essential to the perfection of results. So that, after all, the term "rough" rather implies an absence of "finish" in the patterns than a slight equipment of technical knowledge or absence of accuracy. For rough work as applied in this sense a foreman or employer will provide special timber. While he will use the very best quality board that can be got for the best and standard work, he will provide a certain proportion of seconds for the rougher work of shop tools, core-box sides, boxed-up patterns, and loam-boards.

All patterns should be stamped before they go into the pattern stores. They may be stamped by the name of the piece of work to which they belong, or by some distinctive number, which number is kept in a pattern register, or with both together thus: "4IN. THREE THROW PUMPS. B 482." The letter B has this reference: when the registered patterns have reached a certain number, say, 1,000 or 10,000, an increase in the number of figures is apt to cause inconvenience. Hence, there would be A 1, A 2, &c., up to the limit, say A 1,000; then B 1, B 2, as far as B 1,000; afterwards C 1, C 2, to C 1,000, so that 26,000 patterns might be thus registered. The system is an excellent one, and is largely adopted. The drawback is, that when patterns have been repeatedly altered, as they very often are, for modifications of design and difference in dimensions, these registers become comparatively valueless unless a very complete record of such alterations is kept in the pattern register itself.

Checking Patterns.—This heading may sound superfluous to many, yet it is sometimes amazing the absurd mistakes that can occur. Very little imagination is necessary to visualise the trouble and expense that can follow the production of a batch of castings from a pattern that has been carelessly checked.

It is particularly fatal to concentrate on one important dimension to the exclusion of the remainder. The writer instances the case of an inspector, who with much elaboration proved the profile of the teeth of gear wheels to be perfect, and then forgot to count the number of teeth !

The batch came back to him later, *the gears all having one tooth too many !*

It is best to develop some system of checking, and to rigidly adhere to it.

Working along the lines here suggested has proved very successful.

Never assume that a pattern is correctly made. On the contrary, assume that there are some errors in it. Regard every pattern with suspicion until proved to be trustworthy. This is a safe attitude to take up; the contrary assumption may lead to trouble.

Before measuring anything at all, look the drawing well through, in order to gain a clear idea of the relations of the several parts. Then walk round the pattern, and, taking a general survey of its broad features, see that everything shown in the drawing is also on the pattern; and not only on, but in its proper relation to the other parts. Compare pattern and drawing in their several corresponding views in

succession—plan, elevation, end views, and sections. When you are sure that the general relations of parts are all correct, then begin to measure.

Take first all centres and lengths embraced in one view—plan, or elevation. Don't trouble about other views, but finish one at a time. After the cardinal dimensions, take the less important ones, as minor lengths, thicknesses, diameters, &c., one by one, going over the drawing in detail. Some tick off each dimension as taken, but this is not necessary if contiguous dimensions are followed, and it disfigures shop drawings. When one view has been thus treated, pass on to the next, and so on, until every dimension in every view has been tested.

As regards the methods of taking dimensions, they do not differ essentially from those employed on the marking-off table. Most patterns have to be laid either upon a true bench or on a drawing-board, or on a joint board, in order that the square may be tried up against vertical faces, both to test the truth of those faces and to take measurements therefrom.

A foreman should always insist that centre lines should be scribed, not marked with pencil, which might be easily obliterated. Scribed lines facilitate measurement, and tend to accuracy.

After having checked the pattern dimensions proper, the next thing should be to test the correspondence of prints and core-boxes, and to check the core boxes with the drawing dimensions. Note that the print thickness is allowed in the core-box. Not infrequently it happens that this matter is forgotten, and that the core-box is made minus the print thickness.

As regards the correspondence of prints and core-boxes, it should be noted that they ought not to correspond exactly. In large cores the boxes should be rather smaller than the prints; in small cores the boxes should be slightly larger than their prints. The reason is this: large cores become strained in ramming, and usually come out rather fuller than their boxes, and will then require to be filed before they will go into their prints. Small cores, on the contrary, come out a trifle smaller, owing to the rapping of the box sides, and they are too small to become strained. In small patterns, again, the rapping makes the mould rather large, and therefore the diminished core fits slack into the enlarged mould. Of course, these differences are slight, and for rough work no notice need be taken of them; but in the best work, and standard work, account should be taken of these things, for a close-fitting

core prevents the formation of fins, and of slight movement out of place. On the other hand, when a moulder starts to file a core, the chances are that he will file it irregularly, or take too much off. The precise amount of the difference in size between core-boxes and prints is one for experience. No two moulders or core-makers work alike. One man is more clumsy than another. Then, moreover, the thickness of the coat of blacking counts for something in small cores. Generally, for large cores, make the box a full $\frac{1}{16}$ inch or $\frac{3}{32}$ inch smaller than the print; and in small cores make it slightly fuller, or so that the calipers fitting easily over the print will fit very stiffly on the core.

Important matters in checking pattern-work are, to see that faces are in winding with each other; that parts are duly parallel, or at right angles, as the case may be; that the taper is equally distributed, and that it does not interfere with working parts.

In a rough-and-ready way the truth of faces in the same plane can be judged by the eye. But we often have to check the truth of faces which are not in the same plane, but are situated higher and lower, or which, if in the same plane, cannot be glanced or sighted down directly because of other portions of the pattern, as prints, brackets, and bosses standing up in the way. Then the winding strips alone are available. Do not use short winding strips. Employ them of such a length that they stand out a foot or more beyond the faces which they are checking. Error will then be magnified, and so become quite apparent. If, in a bad light, the edge of the farther strip is but dimly discernible, chalk the upper part of the flat face that faces towards the observer, and the edge will then appear sharply defined.

When trying surfaces that are in the same plane, it does not matter if the faces of the strips are not parallel with one another. But when trying faces that stand higher and lower, the strips must be kept strictly parallel, or the results will be inaccurate. But when checking such higher and lower faces, it is usual to place packing blocks of parallel thickness under the lowermost strip to raise it up level with its fellow.

Again, when checking opposite faces for parallelism, it is not usually accurate enough to take rule measurement down the opposite sides—that is, at right angles with the faces. Two strips should be placed on the opposite faces, and measurement be taken from their extreme limits in order to

magnify any want of parallelism in these faces; or caliper measurement may be made, but the strips are better. In many cases caliper measurement cannot be taken, but the straightedges afford the only means available.

To test the truth of faces at right angles, the try-square alone is often not good enough. Thus, if the face against which the stock of the square is tried is not true, this mode of testing will give erroneous results. And the flat surfaces of patterns are frequently not true, especially in old work. Hence the need of a level board upon which a pattern can be laid, and from which the set square can be tried Or when a try-square is used, its stock should be long enough, or nearly so, to go over the entire breadth of the surface from which trial is made. This may seem a trivial matter, but it is not so; for if the surface upon which the stock is tried is out $\frac{1}{32}$ inch only, then on the length of the blade there will be $\frac{1}{16}$ inch difference, and this will often equal the allowance for taper, or half the allowance for machining.

When putting taper see that it is equalised. This is best tested with a set square and with calipers. It is an axiom that a very considerable amount of taper shall be given to parts that are not working parts, but that the smallest appreciable amount should be given to working faces.

A foreman should always exercise control over the allowances given for shrinkage. There are certain standard allowances given for average work, as $\frac{1}{8}$ inch in 15 inches for cast-iron, $\frac{1}{8}$ inch in 10 inches for brass and gunmetal, and $\frac{1}{4}$ inch per foot for steel. But these are only averages, and every foreman who has had much experience knows as a rule how much these allowances must be departed from for special jobs. The pattern-maker should not take risks, as alterations often prove costly.

Another point is the making allowances for moulders' ways and the straining action of moulds. The pattern thickness for all large plated work should be under size, it thicknesses are required accurate, because such thicknesses increase by casting. All deep moulds become strained also, so that a deep casting will usually come out as deep as the pattern itself, though shrinkage allowance has been given.

The accuracy of the pitch of wheel teeth and their equal thickness must be checked with calipers upon the pitch-line. Their position, as regards right angles, is best tested by laying them flat upon a surface board and trying a set square up their flanks. This is better than using a trying square from

the ends of the teeth. Their accuracy lengthwise should be tested by a small thin straightedge—that is, if they have been cut by hand.

When checking dimensions, do as little arithmetic, adding and subtracting, as possible. Measure, whenever practicable, direct. If, for instance, $2\frac{1}{16}$ inches has to be taken from $17\frac{7}{16}$ inches, let the rule stand over the edge of the work that $2\frac{1}{16}$ inches. This seems a trumpery little point, but its observance will save a blunder in calculation sometimes. For the same reason, when checking a loam board, measure direct from the centre of the job, obtained either by straining a line or by laying a straightedge down it. Do not measure from the edge of the board, subtracting the differences from centre to edge from every successive radius dimension.

Old patterns in a jobbing shop are pitfalls for the unwary foreman. They are not to be trusted, for between previous alterations, shrinkages of timber, and damages in the foundry, they are often altogether wrong. In many old patterns special attention must be given to checking the shrinkage that the stuff may have undergone in the stores since last put away. Many old patterns that should be circular approximate to an elliptical form. They must be altered by gluing a strip on the edge, or, if circular and jointed, by gluing a liner in the joint; if circular and solid, by sawing them down the centre, jointing the edges, and gluing sufficient between the joints to make them circular. Patterns that have been put away in the stores after the first time of using only are much more likely to be out of truth when brought out again than those which have been used several times at considerable intervals. The former are more liable to shrink (the stuff being comparatively new) than the latter, in which the stuff has been well seasoned by time.

Electrolytic Pattern-making.—Moulds for plate work produced by this method have the advantage of uniformity of size and profile. A half-pattern is first made then laid within a wooden frame face downwards upon a surface plate. A special plaster-of-Paris composition is then poured over it. When dry, the pattern is removed and the mould baked dry before being waterproofed. Next it is placed in an electrolytic bath for an average period of four days, depending upon the deposit thickness required, which can be from $\frac{1}{32}$ to $\frac{1}{4}$ inch. When ready it is filled with white metal and then machined flat. Finally the plaster is removed, leaving a smooth half-pattern. Copper is the usual metal deposited.

CHAPTER IV.

ON CORE PRINTS.

Prints not always Required.—Typical Forms of Prints.—Taper.—Depth.—Modifications of Prints.—"Stopping-off."—Boxes.—Coring Various Kinds of Holes.—Top Prints.—Wrought-iron Pieces Cast in.—Chain Wheel Cores.—Importance of Venting Cores.—Decomposition of Water in a Mould.

Core prints are not always necessary. When the cores are large and rest flat on the bottom of the mould, they can be set in position by measurement, and their own weight, or the pressure of the top box, or both combined, will maintain them in position. But usually cores are set in their places by means of prints.

The simplest form of print is the common round or square kind, on which the apprentice makes his first essays. Then, of course, all prints which draw from the bottom of the mould are simply modifications of these, possessing taper, and varying with the shape of the holes they are indicative of. The next form is the pocket or drop print, used for casting holes in the vertical sides of a mould where a common round print could not be drawn up with the pattern. Here, when the core is placed in position, the upper part of the print is filled in with sand flush with the edge of the mould. All prints, however they may vary in appearance, belong either to one or the other of these two types.

Common round prints are tapered in the direction of their depth, the amount varying from $\frac{1}{16}$ inch to $\frac{1}{8}$ inch in their diameter, smaller prints having less, larger ones more, taper. The only object in tapering them is to facilitate their withdrawal from the sand. Their depth varies also, a print small in diameter requiring greater depth than a large one, to steady its core in position, so that while a 1-inch print may be 1 inch long, a print with a broad base, say of 8 inches or 10 inches

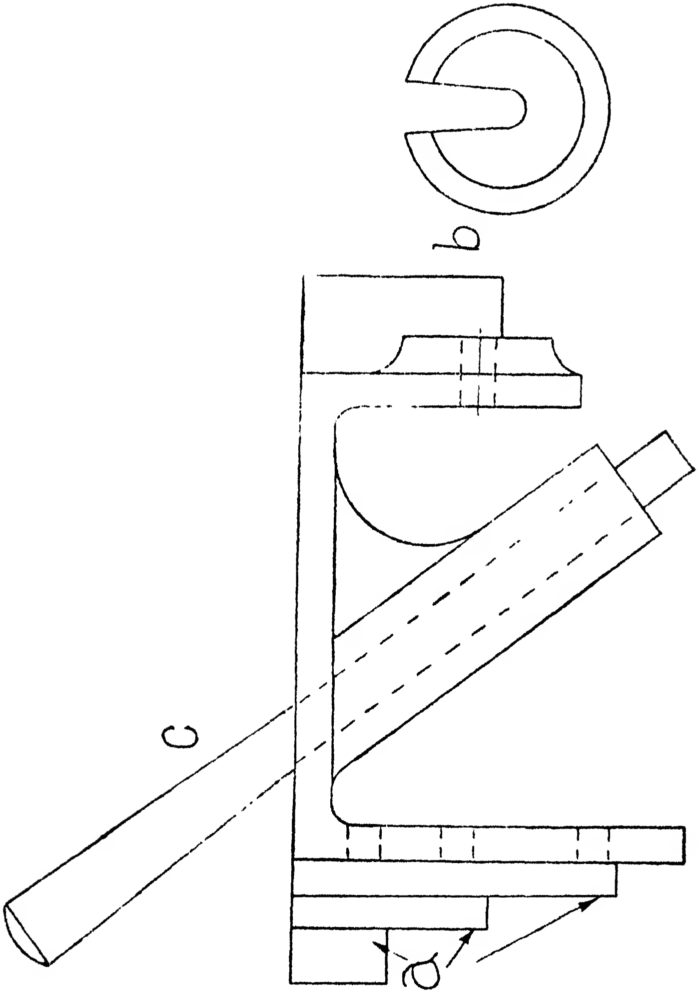


Fig. 102.

in diameter, need not be more than ½ inch thick. The thickness of pocket prints depends upon the thickness of metal through which their cores have to be carried. If we had to cast a hole through an inch of metal, the print should be made 1¼ inch thick, to counterbalance the weight of the unsupported portion of the core. But if the thickness becomes very great we ought to have prints on each side of the pattern, in order that the core might be bridged across the mould. If, however, the core does not go right through the metal, but only a portion of the way, and the unsupported length is too great for an ordinary print to counterbalance, we simply put a print thick enough to resist the crushing of its sand out of shape by the weight of the core, and sustain the opposite end of the core by chaplets. The partly closed box, which sometimes carries a front crane roll, or the cylinder or the plunger for a large hydraulic ram, having one end closed, will illustrate my meaning

Again, we may have three or four holes in the same vertical plane (Fig. 102,*a*). Here we should place pocket prints one over the other, the outer ones being thicker than those within, because of the greater length of core they have to carry. We should scarcely be able to make these outer ones thick enough to entirely counterbalance their cores, but should expect the moulder to hold them in place until they were securely stopped over. "Stopping over" means filling up the upper portion of the print level with the face of the mould, after the core has been placed in position. Where cores of the same size are used repeatedly in one pattern, we make a special box to fill up the print as well as to core the hole out, or, in brief, to "stop itself off" (Fig. 103; see also Figs. 44 and 45, p. 54). It is easily seen what shape the core-box must be in order to fill up the print and take out the hole; the difficulty sometimes is how best to joint it. However, this need offer no real obstacle if we remember that the only object in parting the box is to allow freedom of delivery to the core. So that the various portions of an intricate box can be removed without tearing the core, it matters little in what particular way it is parted.

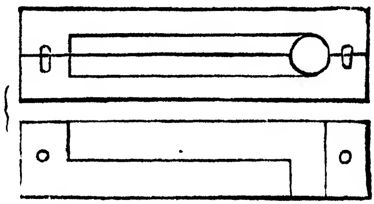


Fig. 103.

Where a print has to be stopped up over a boss, the boss

must invariably be cut out to slip over the print, and not the print cut to fit over the boss (Fig. 102,*b*). This is apparent in an instant in the sand, for then a solid boss is seen to occupy the portion of the print which the moulder desires to fill up.

When a long round core has to stand at an angle in a mould, it is customary to have, in addition to the bottom print, a long tapered one in the top coming right through the top sand (Fig. 102,*c*). Here the core is thrust in through the top after the boxes are put together, and the proper bevel is thereby secured. But the danger is lest some of the top sand should be pushed into the mould by the descent of the core, and, remaining there, destroy the casting. The mould being finally closed, the workman can only rely on his sense of touch. This danger is partly guarded against by making the long taper print at its smaller end ⅛ inch larger than the core, or more effectually by bending a piece of hoop iron around the smaller end of the print, and letting that remain *in situ* to protect the sand. But some moulders will rather sustain the core at its bevel by chaplets, and only use the long print where chaplets are not available.

Where cores are carried in a line through two or more contiguous ribs of a shallow casting, pocket prints are often discarded for a round parallel print placed between the ribs. This involves no stopping over, for the joint of the mould is brought down to the centre of the print, and a long round core insures greater parallelism in the holes than two or more shorter ones would do. The advantage of this is still more obvious where there are deep bosses, projecting inwards, for increasing the length of bearing. These would have to be stopped over were pocket prints used, whereas with a round print the bosses remain intact. But if the sides are too deep to allow of jointing down to the centre of the print, and moreover too thin to allow of the bosses being drawn in, and for some reason or other it is not advisable to joint the pattern itself in the centre of the bosses, the neatest way is to take out the upper half of both boss and print with a core (Fig. 104). A block print stretching from side to side, with its ends well tapered, and a core-box of corresponding size, with half bosses and half print fastened on its bottom board, will then answer our purpose admirably.

In the case of a vertical core disproportionately long in comparison with its diameter, a bottom print is not usually sufficient to carry it steadily in the vertical position. Then we put a top print on the pattern in addition to that on the

bottom. Yet this is usually only essential where it is not easy to check the upper part of the core by measurement. In a common brass bush, even if it be 10 inches or 12 inches long, the moulder can centre his core by measurement, and the top box will keep it in position afterwards. So the core in the boss of a spur-wheel can be checked accurately from the points of the teeth. But a bevel-wheel with a deep boss on the back, or a sheave-wheel one half of which is in the top box, do not afford the same facilities for measurement. So in these and similar cases it is advisable to put prints both on top and bottom.

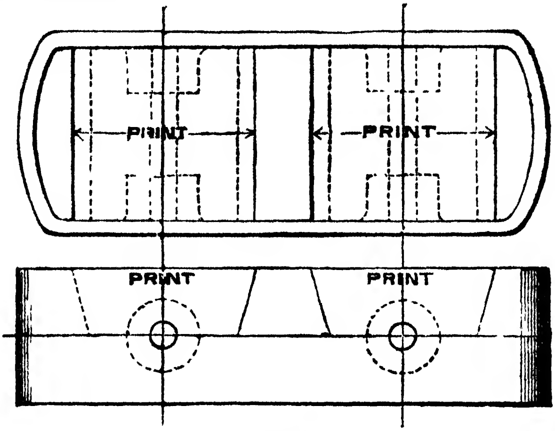


Fig. 104.

We have frequently to cast a wrought-iron eye, handle, pin, or such like, in a piece of work. Here a print precisely similar to a core print will be used, its shape following the outline of the handle, pin, or eye to be cast in (Fig. 105). The spaces. *a*, *a*, left by the withdrawal of the print, are of course filled up with sand before the mould is closed for casting.

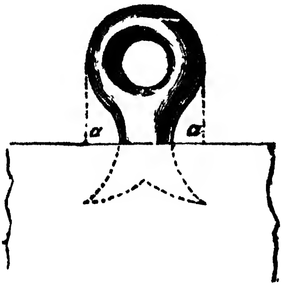


Fig. 105.

Sometimes a hole has to be cast through a thick lug or bracket in such a position that a print on each side is necessary. Yet something else in the way, a bracket, perhaps, or boss, would render the "stopping-off" of the pocket print on one side a troublesome job. The difficulty is avoided by

having a common round print on this side loosely wired on, and by making the pocket print on the clear side about twice as thick as usual (Fig. 106). The core is then dropped into the pocket print, and thrust along into the round print. The vacant space behind and over the core in the pocket print is stopped up with sand as usual.

The rim of a large chain-wheel is usually taken out with cores to save the labour of cutting out a large number of link

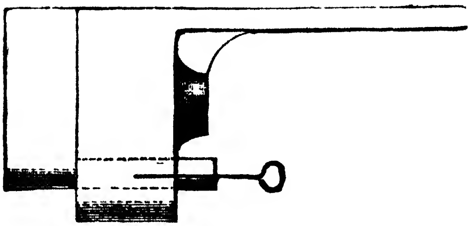


Fig. 106.

recesses in the pattern. Here, and in all jobs where the prints should well support their cores without assistance from chaplet nails, the print should be plenty wide enough.

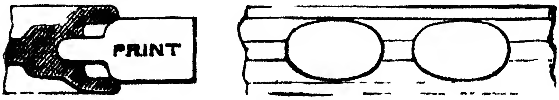


Fig 107.

Give it, say, half as much again of bearing as is necessary to just counterbalance the cores (Fig. 107). Of the core-boxes for these wheels we shall speak in due course

Finally, although the point does not intimately concern the pattern-maker, mention should be made of the importance of providing adequate ventilation of all cores.

A considerable generation of gas takes place when the molten metal is poured into the mould, and, due to the presence of dampness, *i.e.*, finely divided water, the hydrogen becomes separated from the oxygen and then, having considerably increased its volume, escapes with considerable violence out of any vent holes. If any proportion of gas becomes trapped in the mould, a honeycombed or " spongy " casting will result.

CHAPTER V.

CORE-BOXES.

Standard Boxes.—Framed Boxes.—Skeleton Boxes.—
Cylindrical Boxes.

CORE-BOXES afford scope for much variety, in relation to which some remarks are offered.

The plain round, and the square cores are made from boxes which are kept in stock. Fig. 108 shows a standard iron box kept in lengths of 12 inches or more. It is planed in the joint, and bored. Lengths of cores shorter than the box are cut off as required. Fig. 109 is a hard wood box

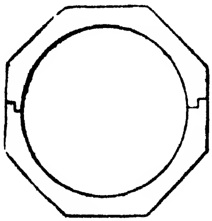


Fig. 108.

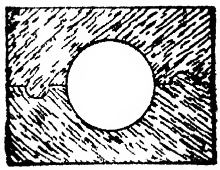


Fig. 109.

for round cores; the same design is also employed for square cores. When cores are larger than 3 to 4 inches they exceed the capacity of the standard boxes. Besides which, the shapes of many cores are such that they cannot be made in these boxes, but special ones have to be made. Boxes for valves, cocks, pipe bends, etc., have to be cut and shaped with gouges, chisels, and other tools, or by a mechanical wood-worker.

The group of Core Boxes seen in Fig. 109A were completed on a Wadkin Pattern Miller (described in Chapter XXIX). The four parts B are seen assembled at A and the complete

box was made in the time taken by a pattern-maker working by old-fashioned methods to finish one part.

The example at C, except for the bosses, represents three hours' work, a saving of twenty hours.

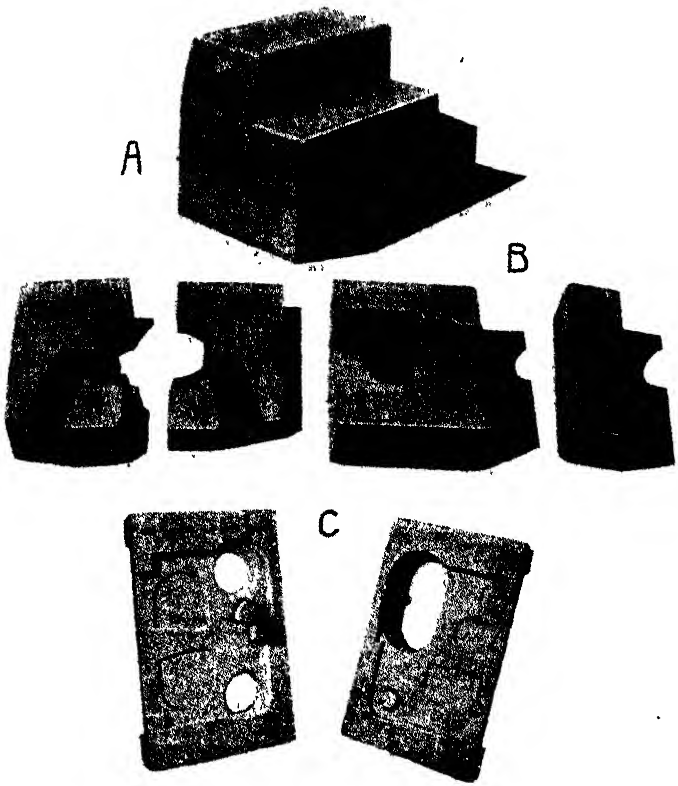


Fig. 109A.

Figs. 110 and 111 show how the framings for rectangular boxes may be constructed. Often such boxes are only main ones into which detailed fittings are put. But in any case the general construction is as shown. In Fig. 110 the ends fit into grooves rebated into the sides. The ends cannot

then become rammed outwards. The sides are prevented

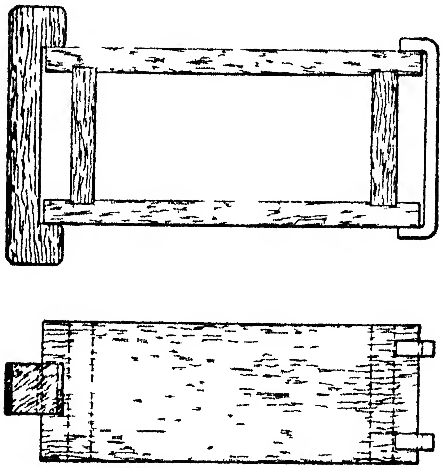


Fig 110

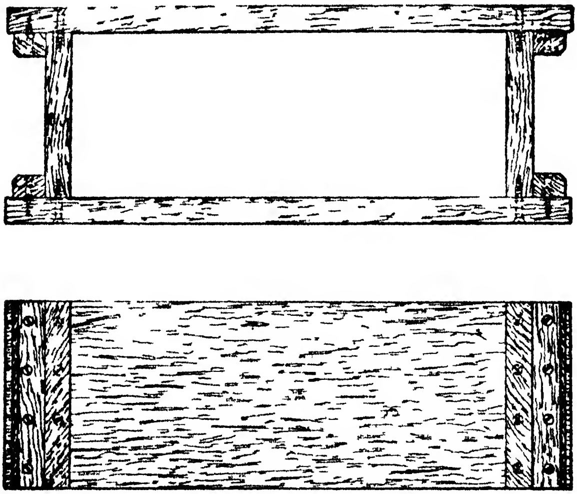


Fig 111

from becoming rammed outwards by the clamps at the ends. These are of wood as seen at the left, or of iron shown at

the right. In Fig. 111, instead of grooving the sides, the ends fit between, and are prevented from end movement by taking a bearing against chocks of wood screwed down the sides. Screws retain sides and ends instead of clamps.

In long and heavy boxes the sides will bulge outwards during ramming. This may be prevented by screwing stiffening ribs down the sides as in Fig. 112, or by the insertion of a bolt at the centre as in Fig. 113. Bolts are

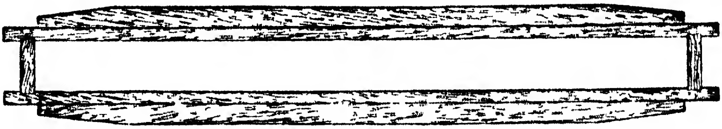


Fig. 112.

shown used instead of screws or clamps at the ends in this figure. These are only employed in very heavy boxes.

A bottom board must often be used for a box, and also a strip or strips on the top. In Figs. 114 and 115 which is the box for a sluice valve, both are shown. The portion which forms one valve face is fastened to the bottom board, and that for the other valve face is maintained in position by two cross-bars screwed or dowelled to the top edges of

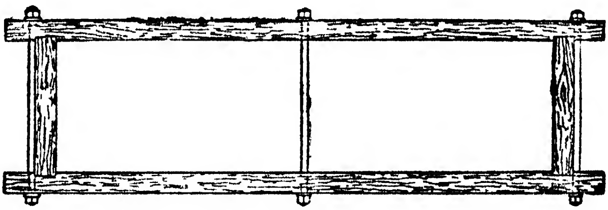


Fig. 113.

the box sides. These are seen in Fig. 114, but removed from Fig. 115.

When core-boxes are of irregular outlines it would often be very expensive to fill in the interior of a square framing with large wood blockings. The same result may be achieved by making a skeleton box, of which Fig. 116 is an example, and strickling the sand to the curved outlines provided by the ends of the box. This is identical with the methods which are common in patterns, of strickling to save timber.

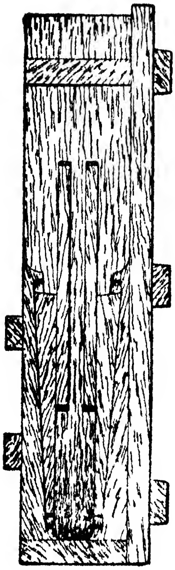


Fig. 114.

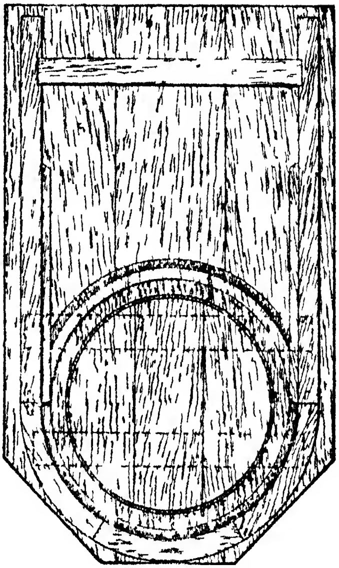


Fig 115.

Fig. 117 is an example of a bottom board and bridge-piece in one box. The principal reason for the combination is the location of a round print to carry a core. But there may be more than one print carried, and also bosses, lugs, facings, etc.

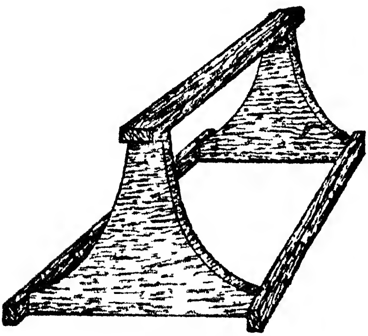


Fig. 116.

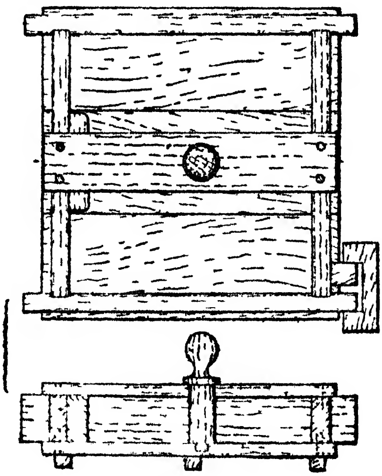


Fig. 117.

In the absence of such fittings the box would not require the bottom board shown, since it might rest by its plane edges on the core bench. Wide bottom boards must be made with narrow strips, open joints, and battens to keep them true. A method of clamping is shown at the bottom right-hand corner, alternative to using screws or employing long clamps to embrace the box width.

Fig. 118 is another example of a rather different class. Neither of the box edges are plane, yet the cost of a bottom board need not be incurred. A shouldered bed of sand can be strickled, and the box laid on that. Or a piece of wood of the same thickness as the shoulder can be laid under it. But if a considerable number of cores is required, a bottom board should be made, as indicated by the dotted outlines. This

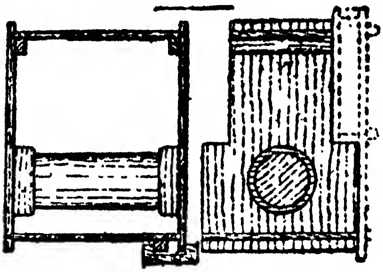


Fig. 118.

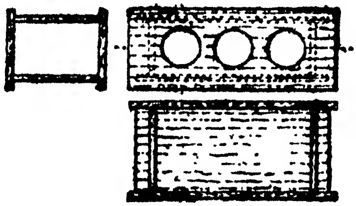


Fig. 119.

box may be screwed at the corners, or short clamps fitted as shown at one corner, if numbers are required. This box carries two bosses, and a long core print between them for the body core of a condenser. Fig. 119 has a bottom and a top board each to receive holes that are rammed in one with the main core. These are located on the framing either with screws or dowells—the latter preferably—or with cleats, either being suitable.

Core-box work, which includes curved and cylindrical sections, is more costly to produce than that in which the sections are rectangular. If cylindrical portions are straight, they can be finished with round planes of suitable radii; but if curved in plan, the whole of the shaping is thrown upon the gouges. A good deal of this is now performed in the larger shops by pattern milling machines (see Figs. 549 and 550).

When an absolutely straight cylindrical section is departed from, the sections have to be worked in detail. In a comparatively plain box like Fig. 120, the halves being fitted with dowels and clamped with dogs, the circles for the diameter A are struck on both ends and worked right through with planes. Before planing, the circle for B is struck, to be cut inwards

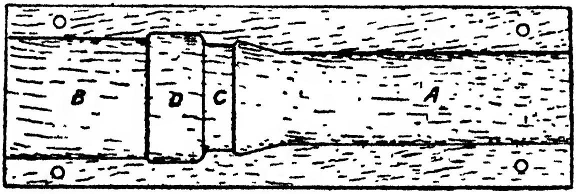


Fig. 120.

afterwards with a paring gouge, guided by lines on the joint faces, and checked with a template.

D and C follow, the guiding lines being on the joint faces only; firmer and carver's gouges being used. The templates are of semicircular shape, or a set-square is employed, guided by the edges in the joint faces.

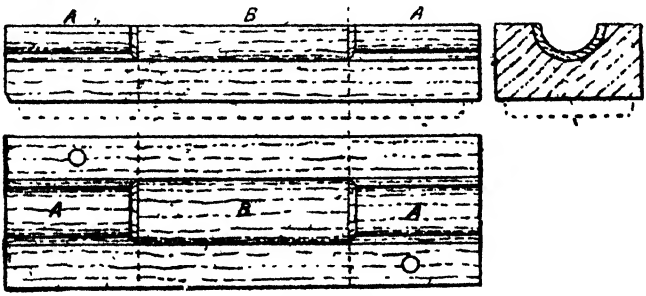


Fig. 121.

For the box in Fig. 121 a similar procedure may be adopted. The portion A may be planed right through parallel in the first place, and then B cut, using firmer-gouges. Since the bevel of the cutting edge, which is on the outside of the gouge, is the face in contact with the work, it possesses no guidance similar to that possessed by a paring gouge. A straight-edge is therefore used for longitudinal check in conjunction with a template or a set-square for circular truth. Another method

is that illustrated. The box is planed parallel through to the large diameter B, and the pieces A are fitted within. These can be turned outside in the lathe, inserted, and worked with paring gouges and planes.

Large boxes for round cores are stiffened with battens outside as in Fig. 122. Without these they would be liable to split along the middle, and would be free to warp. Small boxes without battens are made proportionately thicker at the back to increase their strength. All boxes of this class, whether for straight cylindrical cores or for more complicated forms in which circular cross-sections predominate, are cut in solid halves, never framed up as in square cores. When the thickness of the halves exceeds about 3 inches it is necessary to glue up as in Fig. 123. A thickness not much above that of the thickest wood commonly used in pattern shops can be made as at D; greater thicknesses as at E. Narrow pieces are put on as shown, instead of gluing up a solid block and gouging out the full width. Circles are struck on the ends, and the core shape in the joint outlined for cutting to, and templets are made when these lines are not sufficient. In a plain core,

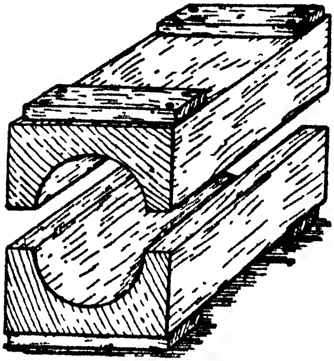


Fig. 122.

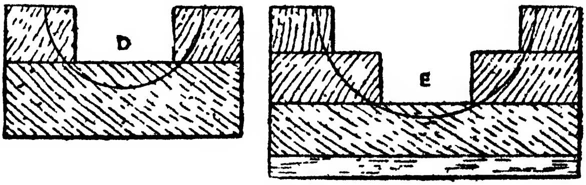


Fig. 123.

as in Fig. 122, it would simply be a case of roughing-out with a gouge, and planing straight through; but often a box is chambered or has branches, and parts may be curved instead of straight. In such cases it is usually necessary to work some portions by templet.

Fig. 124 shows another way of making boxes for small

cores. At F the halves of the box are jointed in line with opposite sides of the core. At G the joint is in a single plane diagonally across corners of the core, which makes it better for drawing the halves of the box away from the core. These methods are only adopted for cores usually well under 2 inches in thickness or width, though their length may be considerably more. It is also suitable for small cores of other shapes, and

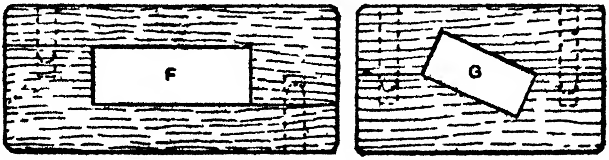


Fig 124.

often when a large number of such cores have to be made, the box is made long enough to include two, three, four, or more side by side, but quite separate from each other. This is better than making a number of separate boxes, and it saves time in making the cores.

Boxes have in most cases to be glasspapered by hand. A cylindrical box can be treated in the lathe in the manner

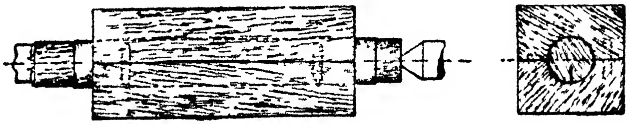


Fig. 125

shown in Fig. 125. A wooden mandrel is turned and covered with a sheet or a portion of a sheet of glasspaper held in a saw kerf. Being revolved, and the box closed over it, the interior is finished smoothly and truly. If a round box has shouldered portions it may be dealt with similarly, by turning the mandrel to the shapes. A slight endlong traverse of the box over the revolving rubber is desirable to prevent grooving.

Of course, in a workshop equipped with modern machinery, as illustrated in Chapter XXIX., the finishing of any shape, however intricate, would present no difficulty. The best handwork cannot compare with that of the machine.

CHAPTER VI.

ON THE USE OF CORES AND DRAWBACKS.

Different Methods of Moulding.—Value of Experience.—Gasholder Bracket.—Drawbacks.—Grid.—Travelling Girders.—Cylinder.—Drawbacks.—Joints.—Lathe-bed.—Column Base.—Head of Crane Post.

The pattern-maker is often in doubt as to the best method of taking out the recessed portions of a casting. Cores, drawbacks, dowelled and wired pieces, are the usual means resorted to for the purpose. Sometimes all three methods are practicable, sometimes only two; rare are the circumstances in which the workman is reduced to one plan without having the option of another. Broadly it may be said that castings can be made from patterns which are exactly like themselves. But in very many instances it would be very unpractical, unwise, and expensive to make them thus. Because a moulder can make drawbacks *ad infinitum*, and form joint over joint, as many as it is possible to put in the pattern, that is no reason why a vast amount of unnecessary labour should be undertaken which could have been avoided by a little judicious coring out.

Yet we need not fall, on the other hand, into the error of taking out everything with cores in order to lessen the difficulty of moulding. For cores are expensive, requiring making and drying, and the core-boxes for a piece of work will very often entail more labour in the pattern-shop than the pattern itself. Looking at the drawing of an intricate piece of work for the first time, it is not easy to arrange everything in detail, and to foresee every contingency that may arise, before deciding how best to make the pattern. Yet there is a rough-and-ready kind of intuition acquired by experience, and it is marvellous how readily a skilled hand will unravel the difficulties of a fresh job, and decide in his mind how he will set about it. Taking the various methods in succession—loose

pieces, cores, drawbacks—he soon perceives which is feasible and which is impracticable; then what is easy and what is not so easy; then, lastly, which is good and which is best of all. So that before the man with less experience has grasped the leading features of the drawing, the other has

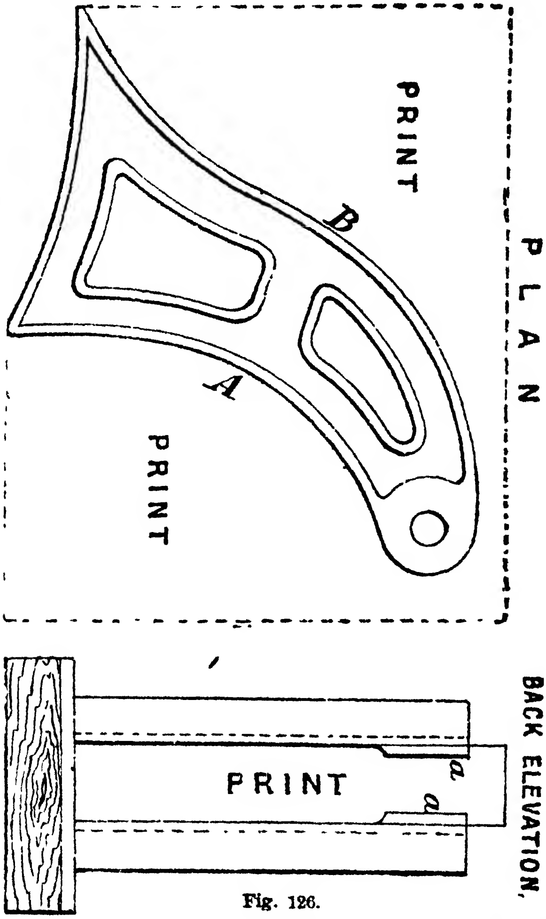


Fig. 126.

already settled in his own mind the lines upon which he intends to work.

But this almost unerring kind of intuition only comes after many years' habitual observation; and also, let us add, after many dearly purchased errors, for here, as elsewhere, failure

is the stepping-stone to success. To apprentices and young hands there is nothing which presents such difficulty as this of the best method of moulding; and, in point of fact, it is seldom left to their choice. When the foreman gives out a job he will almost invariably, except in very simple work, give directions as to the way in which it is to mould, and even then a watchful supervision is necessary with the less experienced hands. It is to help such as these in the matter of moulding that this chapter is written. The simplest way, perhaps, will be to illustrate our meaning as we go along by examples taken from actual castings.

Take, for instance, a double bracket (Fig. 126), such as is used for carrying the guide-wheels of a gasholder. Here is a casting whose pattern might be made to mould with the edge

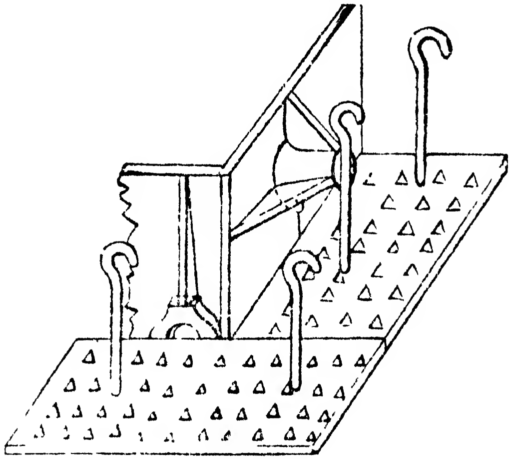


Fig. 127.

A in the bottom and the edge B in the top. Certainly the fillets or flanges round the edges would not allow of the pattern being drawn, but the sand forming the entire sides, including their bounding edges, could be drawn away on plates or "drawbacks."

The meaning of this curiously applied term is seen in Fig. 127 which represents two drawback plates laid against a pattern. On one side of the pattern is a long boss with ribs, on the other a thick bearing with its bracket. We suppose, as often happens, that there is not sufficient central space to draw these projecting pieces into—that cores would mean more

work than the job is worth, and that the sides are too deep to allow of jointing down from the top. Then we ram the sand around these particular sections of the pattern upon these plates, dividing the sand on each plate from that on the other

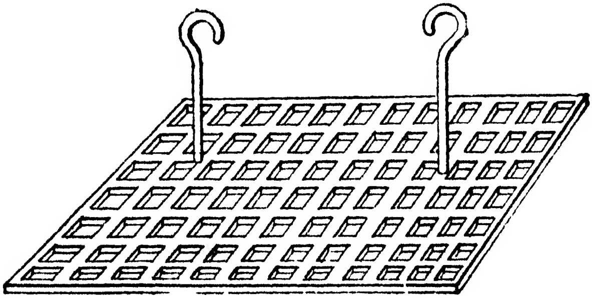


Fig. 128.

and from the outer sand by joints of brown paper or of parting sand, and afterwards "draw back" the plates, with their complement of sand, from the pattern. The pattern is then lifted out and the face of the mould cleaned and blacked,

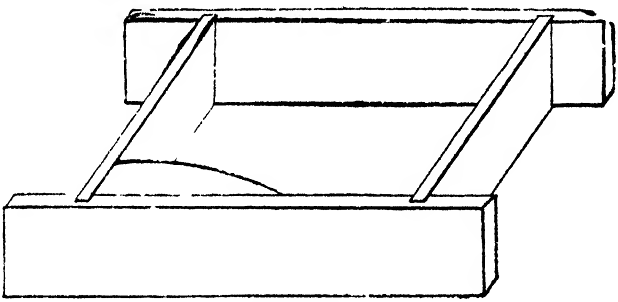


Fig 129

after which the plates are brought into position again by the paper or sand joints.

We could make the pattern of the guide-roller bracket to mould thus, but we should not care to adopt this method in this case. For the drawbacks would be large and heavy, and the flanges and inner edges of the pattern being square would tear away the mould, there being a vast difference between lifting a pattern out of the mould by gently tapping, and tearing the sand forcibly from the pattern. We should find drawbacks expensive in this case.

But it might be made to mould flat side down, just as represented in Fig. 126, plan, in which case the middle space (Fig. 126), back elevation, would have to be taken away on a "grid," of which Fig. 128 gives a sketch. One side of the pattern would then be left loosely dowelled to come away in the top box, and temporary distance blocks would maintain the sides at their proper width apart during ramming. Yet neither would this be a wiser course to adopt in a pattern of so flimsy construction, though it would be well suited to a stronger piece of work. In this case no two castings would come out alike, but the sides would be winding and not parallel with each other. We should, therefore, taking these things into consideration, unhesitatingly vote for a central core (the outline of which is indicated by the dotted line). Then our double bracket would mould on its side, as in Fig. 126, plan; the core-box being plain (Fig. 129), would involve little labour, and the distance between the frames (maintained parallel by the core-print) would be perfectly uniform. The facing bosses,

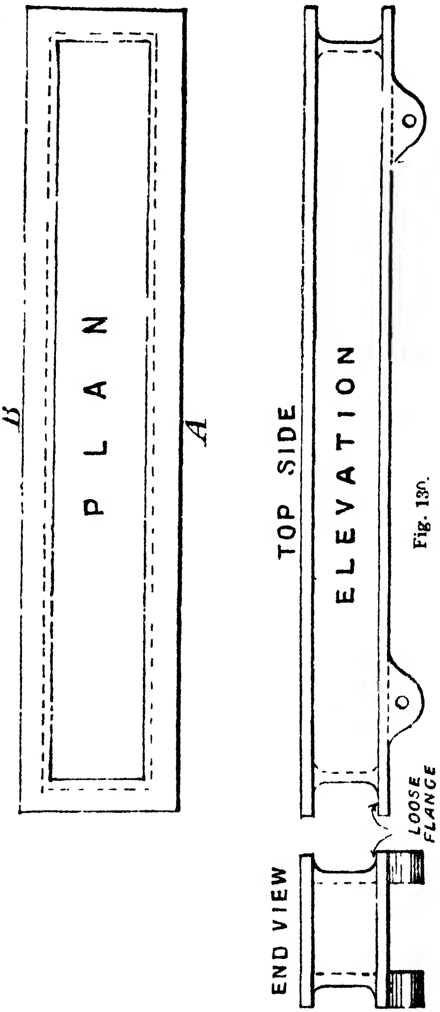


Fig. 130.

a, *a*, will either be put, one on a bottom board, the other on a crossbar dowelled on the top edge, or be measured into place while the core is being made. Of course the top pattern frame would be dowelled upon the print.

Take next a type of cast-iron girder used at the ends of the gantries in overhead travelling cranes (Fig. 130), and which carries the flanged running wheels. Should we take out the centre in this case with a core? The frame in this instance also is double, with a central space, and here analogy would lead one at first sight to think it advisable to mould it upon its side, making A the bottom and B the top, and to take out the central space with a core. But no; here we should use neither cores nor drawbacks, for although we cannot leave the bottom flanges loose round the edges, for the simple reason that owing to their width they could not be drawn inwards, we can leave the entire flange, made as a frame, loosely dowelled to the bottom edges, to be parted from the rest of the pattern by a sand joint. So our pattern will be exactly like the casting in this case, and the trouble of making a plain sand joint will be far less than that of making prints and a core-box, and preparing the cores besides. Fig. 131 shows the pattern in sand completely rammed up.

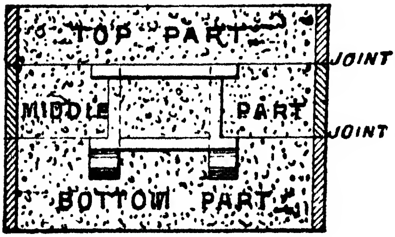


Fig. 131.

Take another form of travelling girder (Fig. 132), where,

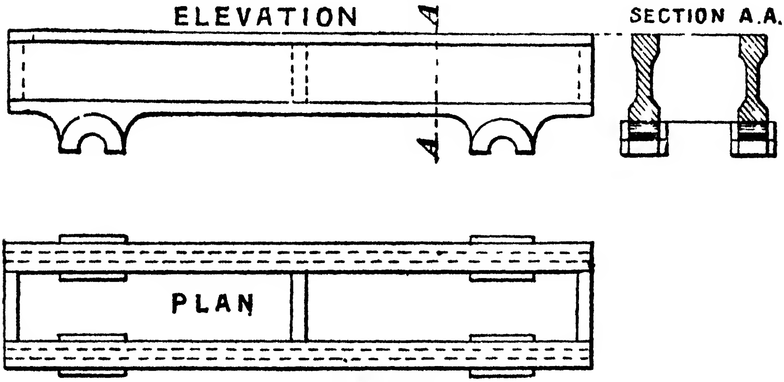


Fig. 132.

instead of broad flanges, we have thin fillets, and bearings whose faces stand out beyond the fillets. Here we should leave bottom fillets and bearings loosely wired on, both inside

and outside. Our sides are, say, $1\frac{1}{2}$ inch thick, and our fillets 1 inch. These latter would draw into the space left by the pattern after its withdrawal; but if, as we will suppose, the bearing-blocks stand out an inch beyond these, they clearly will not come up through $1\frac{1}{2}$ inch space. But we can get over the difficulty of increased thickness in one of two ways here. We could put the blocks on, 1 inch thick, outside the fillets, not screwed, but wired, and draw them *after* the fillets; or we can take away the middle sand on plates, after the sides of the pattern are withdrawn. In a shallow pattern the former entails least trouble; but in the case of a deep girder the latter is the one to be chosen, since it has this great advantage—that both the outer and inner mould is more readily accessible for mending up, blacking, and so forth, when the middle sand is removed than when it remains *in situ.* Fig. 133 shows the pattern rammed up.

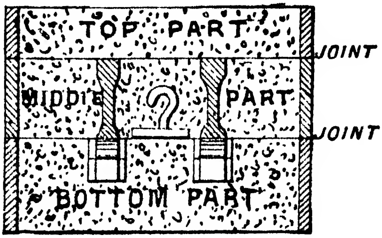


Fig. 133.

The cylinder (Fig. 134) as used in vertical steam cranes affords an illustration of drawbacks, loose pieces, and cores in one pattern. Observe the shape of the feet, A, A; clearly it will not mould on either side, because the cranking of the feet will not allow them to be drawn into the pattern space, and the sand overlying them will prevent their coming up with the pattern, no matter whether we joint it through the plane of the passages, B, B, or parallel with the steam-chest face, C, C. An accurate core, moreover, would be a troublesome thing to make, for it would have to include the entire foot with its bracketings, its bottom face of course excepted. But there is no difficulty if we use drawbacks, and they are very readily manipulated here, D, D. Fig. 134 shows the pattern completely rammed up in a three-parted box, with joints and drawback plates shown. The section is supposed to be on the face of the cylinder flange. Fig. 135 shows the middle and bottom parts of the mould when the cylinder body has been removed and the drawbacks are lifted out, but before the feet are drawn or the middle box parted from the bottom. The section is taken through the middle of the exhaust, the feet, and the steam-chest flange. The exhaust flange and that portion of the body above the foot are in the drawback (not shown), so

that that portion of the mould shows a clear space right down to the flange. Fig. 136 shows the right-hand drawback lifted out. The left-hand one, of course, will be similar, except that it will contain also the exhaust portions just mentioned.

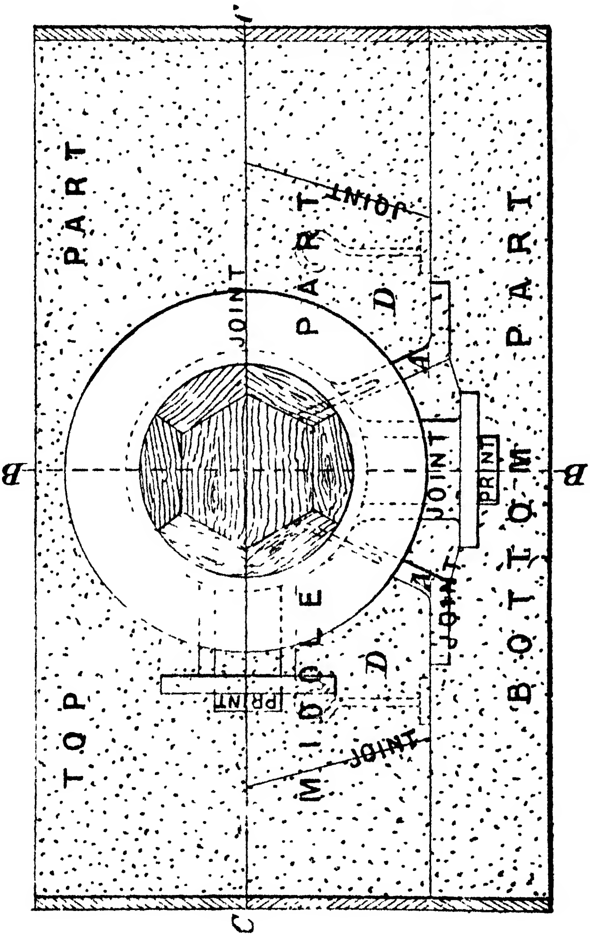


Fig. 134

Then, further, we must either core out underneath the steam-chest flange or leave it loose. A core would be far too troublesome, so by leaving that flange loose we can joint underneath it, and draw the half-pattern from one box and the flange from the other. And the steam passages must be

taken out by cores, the prints for which will be placed on the flange.

The more completely to illustrate this chapter on the diversified methods of moulding patterns, let us discuss the different methods in which a lathe-bed might be made. Every one

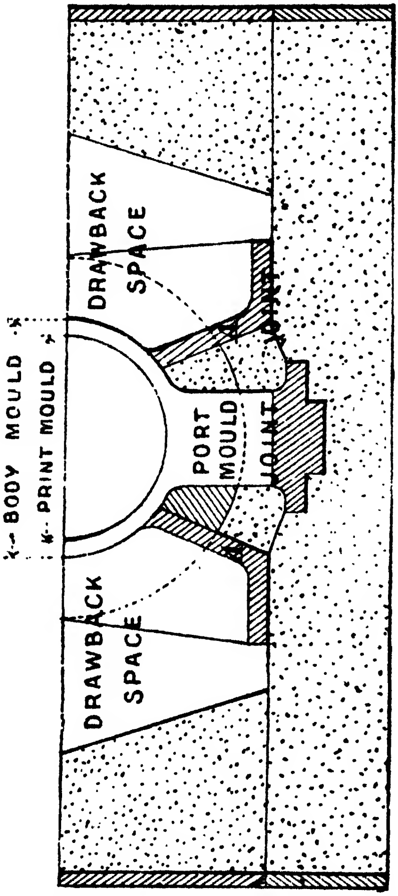


Fig. 135.

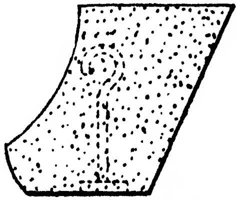


Fig. 136.

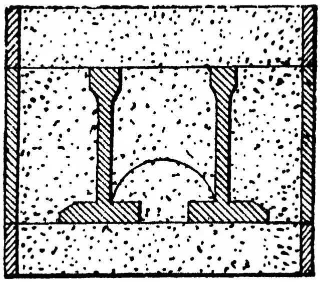


Fig. 137.

knows the familiar form of a lathe-bed, with V-shaped edges for the saddle of a slide-rest. The V-strips are planed all over, and that settles at once their position in the mould. They will be in the bottom, to secure the advantage of the soundest and cleanest metal.

But we require to settle something beside the fact that the strips are to be cast downwards before we commence the pattern, and that is, how to taper the sides. Looking at the imaginary mould in section, Fig. 137, we see clearly that,

though the sides of the bed can be made to withdraw readily from the sand, it is impossible to lift out the inner and outer bottom strips through the spaces left by the sides. Hence our idea would be to remove some portion of this overlying sand, and so render the strips accessible. From this point of view the pattern could be constructed in three different ways, in order to provide for three methods of moulding and the ready removal of the strips in each case.

The three diagrammatic views, much exaggerated, will clearly illustrate these three methods. In the first instance (Fig. 138) we plane no taper in the stuff which forms the sides, but give, instead, $\frac{1}{4}$ inch to $\frac{1}{2}$ inch of taper (according to the depth of bed) to the ends of the bridges or crossbars, so that the bed shall spread bodily in section. Here the sand forming the inside of the bed will be lifted away on plates,

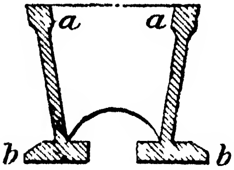


Fig. 138.

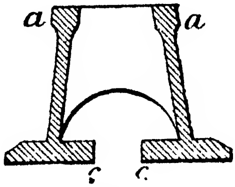


Fig. 139.

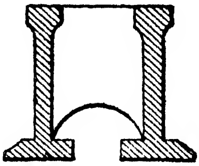


Fig. 140.

after the removal of the top box, and the pattern itself will be drawn immediately afterwards. The fillets, *a*, *a*, would have to be wired on to lift with the inner sand, and the outer Vee's, *b*, *b*, would also be left loose to be drawn into the middle space left by the lifting out of that sand.

The process adopted in method two (Fig. 139) would be the same in principle as the first, but the *modus operandi* would be exactly the reverse. Here the outer sand would be lifted away, either on drawbacks or on an outer encircling plate; then the pattern would be drawn, leaving the middle sand remaining. In this case the inner strips, *c*, *c*, and the outer fillets, *a a*, would be left loose. In the third method (Fig. 140) the median lines of the sides are parallel, and taper is given to their inner and outer faces. The bottom strips, both inside and outside, are wired on, and the screws which unite the sides to the crossbars are withdrawn one by one as the ramming goes on, and when all is rammed up and the top lifted away the pattern is drawn piece by piece, leaving the sand behind. Then either middle or outside is taken away on plates.

and the loose strips drawn in. Fig. 141 shows an encircling plate as used for lifting the outside of a mould away bodily.

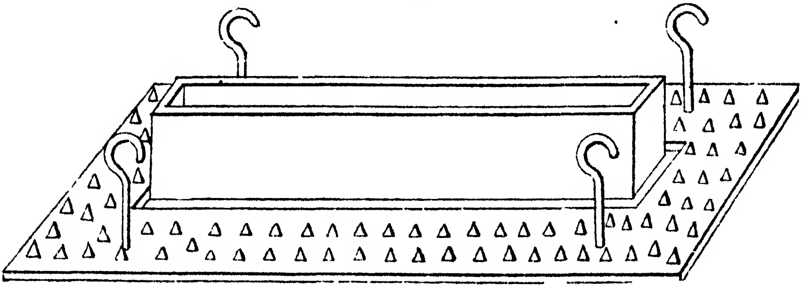


Fig 141

The last method is to take out the inside with cores (Fig. 142). It makes a cleaner and truer casting, and as the cores are very plain the expense is not great. Only the outer pieces, *a*, *a*, are wired on. The core-box may be made of the *entire* length of the pattern, and the bridges put in, as into the pattern, or short core-boxes may be made to reach from bridge to bridge.

Some readers may be disposed to put the question, Why lay so much stress in matters of moulding, instead of describing simply how such and such patterns are made? The answer is that in most jobs, scarcely any two men would go to work in precisely the same way. A pattern-maker must understand moulding well, and even here the usages of shops differ. The bare description of one pattern would be of little assistance in the construction of another, having perhaps general resemblance to that, yet differing from it (from the moulder's point of view) in some very important particular. There is no trade where the methods of working differ so widely as in pattern-making. Many patterns can be made to mould in three or four different ways, and the workmen, therefore, instead of proceeding in certain set grooves, like those of many handicrafts which will occur to the mind, must devote to each new job some amount of originality of thought and modification of construction. It is for this reason that piecework is so difficult of adoption in the pattern shop.

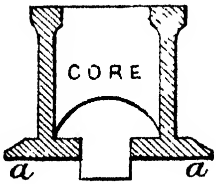


Fig 142

Fig. 143 illustrates the base of a large column. At the corners of the flange there are thick lugs for hold-down bolts, and there are several deep brackets. The flange is 2 inches thick and 2 feet 8 inches square; the lugs are 4 inches thick at A¹, and have holes cored through them. To draw 4-inch lugs or bosses back and up into a 2-inch thickness of flange, at a depth of 16 inches from the joint face of the mould, is an awkward job, necessitating cutting the boss or lug into three thicknesses, each thickness having to be drawn separately back and upwards, and the round print would have to be drawn

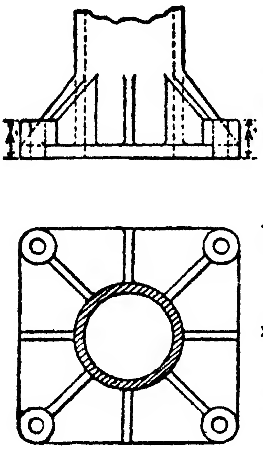


Fig. 143.

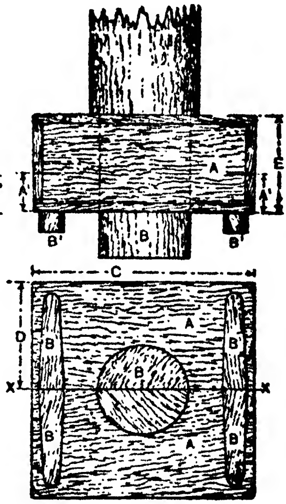


Fig. 144.

back finally also. The moulder cannot see properly what he is doing, and if the sand fractures he cannot mend it up. This is the principal difficulty. But the deep ribs also, standing angularly against the flange, are weak elements, the sand between having to be well rodded. Now, if a core-print is made continuous with the outside of the flange, and wide enough to include the brackets and lugs, and two cores are made and inserted, one in top and one in bottom, the whole difficulty is got over, and a very good, clean casting is the result. This is the way, therefore, in which these columns were cast.

Fig. 144, A, shows the pattern block with its method of construction, which is that of boxing-up. The block measures 2 feet 8 inches square, the same as the flange, and it is made continuous, E, to the same dimensions, to go a little way past the termination of the brackets on the casting. The distance A^1 represents the distance from the face of the flange to the terminations of the lugs, corresponding with A^1, A^1 on Fig. 143, and the curvature of the flange corners and of the lugs is imparted to these portions of the pattern. A hole is cut in the block, which is divided, and dowelled along the joint X—X, to fit over the print B of the pattern column. Pocket or drop prints B^1, B^1 are nailed on for the boltholes. Round prints on corresponding centres are put in the core-box.

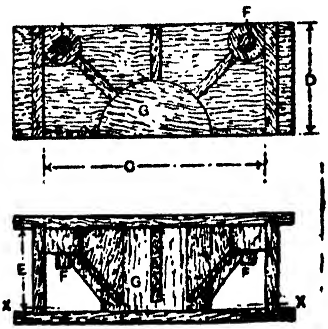


Fig. 145.

Fig. 145 shows the core-box with the lugs and brackets inserted. The upper portion is a section on the line X—X. Two such cores form the base. The dimensions C and D correspond respectively with the dimensions similarly lettered in Fig. 144. The dimension E in Fig. 145 is less than the dimension E in Fig. 144 by the thickness of the flange in Fig. 143. There are round prints F, F on the lugs to correspond in centres with the drop prints B^1, B^1 in Fig. 144. The round cores are dropped into the impressions left by the pocket prints, and slid along into the impressions of the round prints. The block G is of the same radius as the pattern body in Fig. 144, causing the hole in the half-cores to correspond with the main body of the column. Instead of inserting this semicircular block G, holes of the same radius might be cut in the core-box sides, and the semicircular holes in the cores be strickled, the edge of the strickle being guided by these holes.

In Fig. 146 the head of a warehouse crane-post is cored, not because the pattern would not deliver readily if made like its casting, but because a block print is necessary to afford support to the otherwise very flimsy bearings and brackets. The core-box is shown in Fig. 147 to match the rectangular block print in Fig. 146. This print, A, boxed-up, is seen to be fitted over

an extension of the turned pattern column, and on it and the column the shaft bearings and the supporting brackets are fitted as shown, making a sufficiently strong pattern structure, the details of which are shown clearly by the timber shading. The box in Fig. 147 corresponds in outline and dimensions

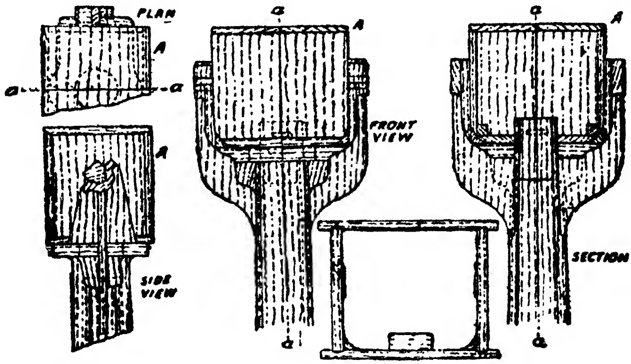


Fig. 146. Fig. 147.

with the print A. No bottom board is required. The two thin facings seen are there to complete the thickness of the shaft bearings, and two large radii are for the brackets. The round print in the box is used to fit the core on the end of the column core, so centring the latter at that end without having recourse to chaplet nails.

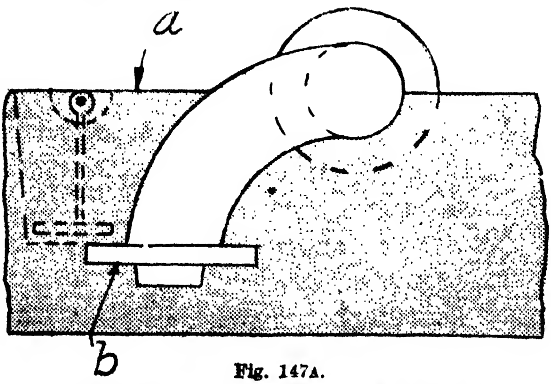


Fig. 147A.

Another example, where, due to the arrangement of the pipe flange, a drawback has been necessary at *a*. The flange *b* is made in several pieces to facilitate removal.

CHAPTER VII.

MOULDING BOXES.

Moulding Boxes.—Their Proportions.—Details of Parts.—Variations in Type.—Box Parts.—Dimensions.—Pattern Work for.—Swivels.—Lugs.—Grids.—Back Plates.—Core Rings.—Snap Flasks.—Gaggers.

MOULDING boxes or "flasks" are rough articles which any one can make; yet, like everything besides, if one were told for the first time to make a pattern for one of these, he would be in doubt what proportions to give to it.

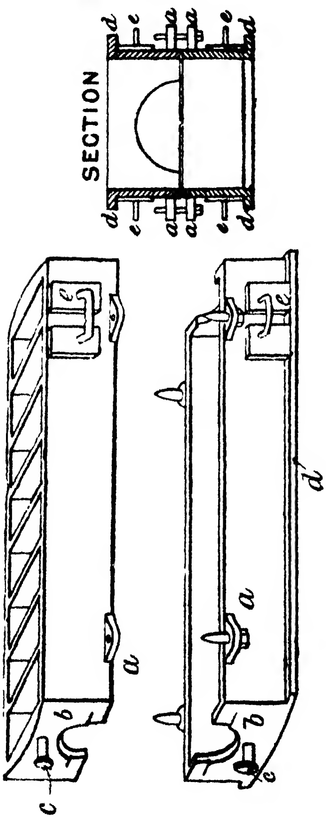
In the first place, then, the size and shape of the box will be decided by that of the pattern which has to be moulded in it. There should be two or three inches of sand on each side of the pattern in the narrowest portions, and from three to six inches on top and bottom—less in the case of small boxes, more in that of larger ones. It is most essential that a box should be rigid, even if that involves more cost in metal and some extra ramming up of sand. There is an immense fluid strain on a large moulding box when the metal is being run in = head × sp. gr. × superficies of mould. Also in the lifting about and turning over of the box, with its weight of contained sand, there are considerable straining forces at work. A flimsily proportioned box will spring, causing portions of sand to become loosened, to the endangering of the mould and the casting. The liquid pressure of metal will also tend to open its joints and make the casting disproportioned. For these reasons the metal in a moulding box should be heavy in proportion to its size. A box soon pays for itself, and the metal is always worth its first cost.

Usually the top part of the box has vertical bars, and, unless in cylindrical work, the bottom part flat bars. In boxes for cylindrical work there are vertical bars in both top and bottom. If there is a middle part it is usually without bars. The vertical bars should be brought within about $\frac{3}{4}$ inch of the

joint edge of the box, and within the same distance of the pattern they are to inclose. The edges of the bars next the pattern are chamfered (Fig. 148). They may be placed from five to seven or eight inches apart in the box, contingent upon size and circumstances. In common with the box sides, let them have plenty of taper—from $\frac{1}{8}$ inch. to $\frac{1}{4}$ inch.

Fig. 148.

Strong lugs are placed at intervals on the box sides (Fig. 149, *a*, *a*), to carry the pins which connect the parts together. During casting the latter are kept close, either by weights or cottars; in the latter case cottar-ways are cut through the pins. Swell pieces (Fig. 149, *b*, *b*) are put on the ends to impart strength and to give extra thickness for the swivels, *c*, *c*, to carry which pocket prints are fastened on the swells. Flanges are often cast round the top and bottom edges, *d*, both for convenience of turning the box over and for the attachment of flat stay plates to support the sand in deep vertical casts, such as cylinders and plungers. For lowering boxes into the foundry pit by the crane, or for rolling over, handles, *e*, *e*, are often cast on the sides, to carry which pocket prints will be needed.



Figs. 149.

But the forms of boxes vary widely, and the patternmaker has to exercise his judgment both in designing and in making complete patterns, or sectional parts for them.

The aim in a well-regulated foundry is, not to multiply the number of boxes more than is necessary. But this main object is controlled largely by the class of work which is done in a firm. Jobbing boxes, that is those which are taken and used for various odd jobs that come in, are only suitable for those shops which do a general class of work. When a

firm's work is specialized, or when certain sections of it are specialized, then special boxes are made, each box to suit one pattern or group of patterns.

The box illustrated in Fig. 149 is a standard one suitable for pieces of work of greater length than breadth, and it would be employed for short lengths of pipe, short columns, stanchions, etc. But for many kinds of work the semicircular bars in the top would interfere with patterns that would otherwise go in the box, *e.g.*, girders and other examples of sections mainly rectangular. For dealing with these, vertical bars are still retained, but they would be shallow. Sometimes then they stand up a long way from their patterns and deep liftering has to be resorted to to sustain the sand. But when long pipes and columns have to be moulded, such boxes, even though of sufficient length to take the patterns, would be very

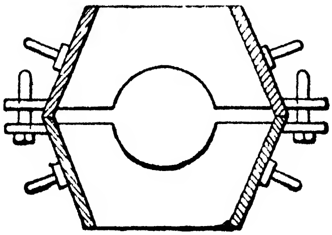


Fig. 150

wasteful of labour and sand. Boxes having tapered sides, Fig. 150, are made for these; each taking one standard size, or two or three standard sizes of pipes or columns, according to the volume of work done. In the standard boxes the bars are cut to come within $\frac{5}{8}$ or $\frac{3}{4}$ inch of the pattern everywhere, the aim being to lessen sand, liftering, and weight.

In the case of very heavy boxes a compromise is sometimes made in order to lessen the storage room required and the weight of metal. Box frames are cast entirely destitute of bars of any kind, and loose bars are fitted with short flanges, through which bolts attach them to the frames. In very large boxes the frames themselves are occasionally cast in four pieces,—two sides and two ends, and united with bolts passing through flanges. These devices are not suitable for boxes in constant service, but for those only which are required at occasional intervals.

The type of box shown in Fig. 149 is a "two-part" one, comprising "top" and "bottom," or "cope" and "drag." But many moulds require three or more parts, top, bottom, and "middle," or middles, since there is often more than one of these. Fig. 151 represents a box of this class, comprising top A, middle B, bottom C. The plan view above is taken through the middle. The top has vertical bars coming within $\frac{3}{4}$ inch or 1 inch of the joint face, the middle has no bars. but internal flanges which assist in retaining the sand in place, and upon which also rods are often laid to assist in supporting the sand, or upon which grids are laid. Such boxes are kept in a large range of dimensions, some oblong and some square, in sizes ranging from about 2-feet to 12-feet or 16-feet, depending on the classes of work done in shops. The depth and

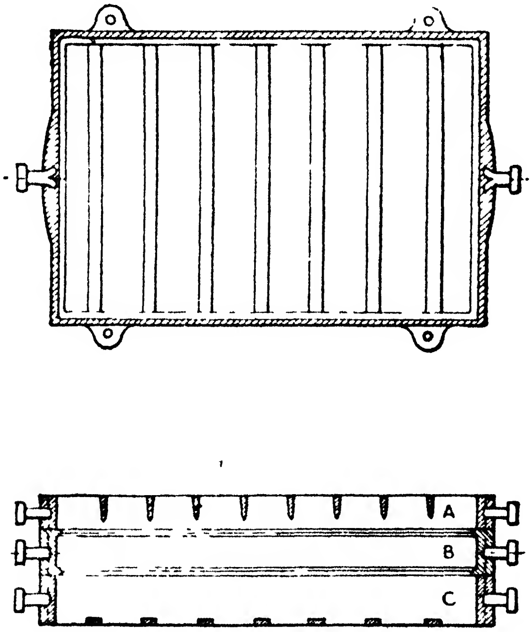


Fig. 151.

thickness are suitably proportioned to size, so that while a 2-feet box may have its "parts" from 4 to 6 inches deep, by $\frac{3}{4}$ inch in thickness, the parts of a 12-feet box would be from 10 inches to 12 inches deep and $1\frac{1}{2}$ inch in thickness. Usually two or three middles are made for one top and bottom, all

mutually fitting for convenience in making up boxes for deep work. This is better for general service than making one deep middle, which would be useless for shallow moulds.

Sometimes a middle part is utilized as a bottom part by bolting a grid frame on one of its faces. This is easily detachable, leaving the middle intact.

The general arrangement of flat bars in boxes is seen in Fig. 151, p. 103. As they always lie upon the floor, the sand in the bottom is thus adequately supported. In the top, such bars would be useless as supports to the sand, and they would, moreover, interfere with the work of ramming. The vertical sides of the top bars do not interfere with ramming, while they afford large faces against which the sand is held by friction. The distances at which they are fixed apart are proportional

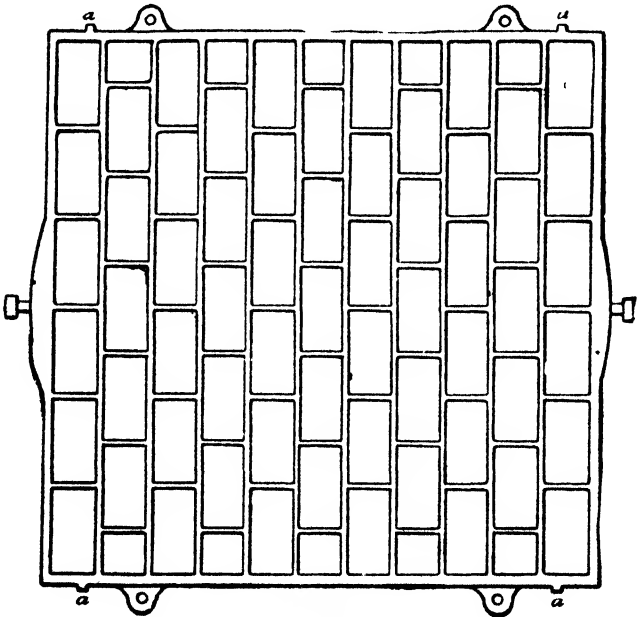


Fig. 152.

to the sizes of boxes, ranging from about 4 inches to 8 inches. Except in the smallest sizes only, cross bars are also fitted, the arrangement of which is shown in Fig. 152, which is a top fitted with strips, *a*, against which stakes are driven into the sand when work is moulded by bedding in the floor.

Frequently the central portion of these boxes for a space of 16 to 20 inches is left as a square space destitute of bars, to facilitate the bringing off of a large central vent, or vents, or for inserting a runner and vents, see Fig. 154. In boxes made for special castings only the bars are arranged to suit the runners, risers and vents.

The smallest boxes used by iron and brass moulders have no bars, but are cast with internal fillets, Fig. 153, which, with the friction of the sand against the box sides, are sufficient to sustain it. The smallest boxes are cast without handles, those of from about 12 inches to 18 or 20 inches are cast with looped handles of wrought iron.

Circular boxes are properly used for circular work, as being more economical of sand and labour than square ones. A plan-view of a circular top is shown in Fig. 154. These are

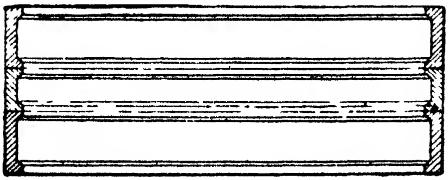


Fig. 153.

made as top and bottom only, or top, bottom and middle, similar to other boxes.

As a general rule full patterns are not made for moulding boxes. The method of procedure is as follows:—The pattern framing is made about ¾ inch deeper than the actual box casting when the mould is to be made in open sand, in which case the metal is not allowed to quite fill up the mould. The various outer attachments are fastened on, and mould with the framing, but the bars are moulded in detail. Three bars are prepared, with cross bars if such are required, and the moulder rams up two of these at a time, setting them by marks, scribed on the top edges of the box framing by the pattern-maker. When two bars are rammed they are withdrawn and removed to the next position and the third bar is inserted in the mould adjacent to prevent the sand from becoming rammed down there. The economy of timber and time which is effected by the adoption of this method is considerable in long and large boxes. Only in the case of boxes the bars of which have to be cut closely to irregular contours, as in the case of some standard work, is it necessary

to fit all the bars in the pattern box. In these rough foundry patterns varnish is not used; often they are left rough from the plane. Sometimes, however, in these, as in other heavy

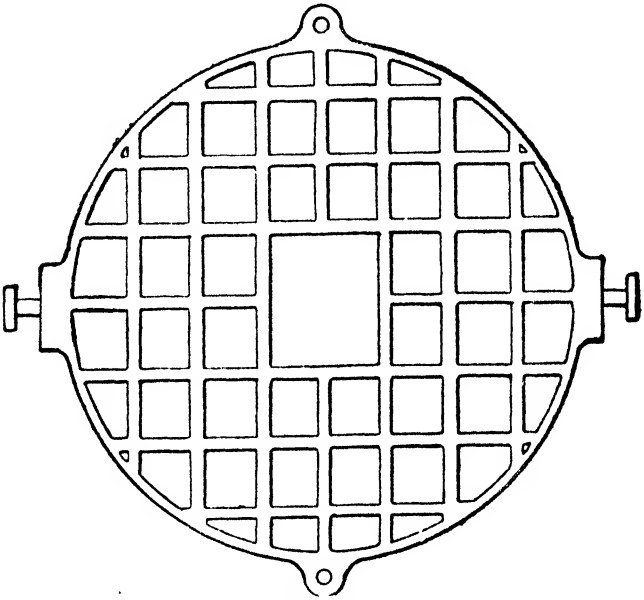


Fig. 154.

patterns, the deeper faces are seared with a hot iron, sufficiently hot to scorch, smoothed over the surface.

The swivels and the looped handles of wrought iron are cast in place in prints of suitable shape. Pocket or drop prints are used for the first, and prints of the same shape as the loops for the second. The ends of these are divided out as seen in Fig. 151, p. 103, and jagged to enable them to hold better. The metal also is increased around them.

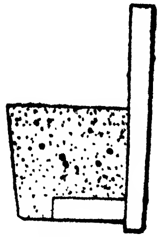


Fig 155.

Lugs may be drawn inwards, but they are better made in cores. The section of a core and lug is seen in Fig. 155. Standard boxes for lugs of each size are properly kept in the foundry.

Grids are moulded from standard pattern grids of fair size, larger ones being made by shifting the pattern, smaller ones by stopping off.

Snap flasks, Fig. 156, the last development, are used to a rapidly increasing extent. They are only suitable for moulds up to 16 or 18 inches square.

The object in using these is to save the cost of flasks. By the employment of snap flasks the cost of separate boxes for each one is saved, besides which time is not wasted in knocking out moulds. Two, three, or half a dozen snap flasks are sufficient, depending on the number of machines in service. The moulds are rammed, or pressed in these. Each half of the mould has an iron ring or frame rammed in it to retain the sand. The moulds being made, the snap flasks are unfastened and opened, leaving the moulds self-contained and ready to be laid on the floor for pouring.

Back plates are made in open sand from open framed patterns strickled out in the centres. The holes are cored by measurement, often without prints, the cores being retained in place by an iron bar serving as a weight.

Core rings are moulded from sweeps supplied by the pattern maker, the prods being stamped from a standard pattern prod.

Manufacturers of foundry equipment, however, now supply a variety of flasks at very competitive prices.

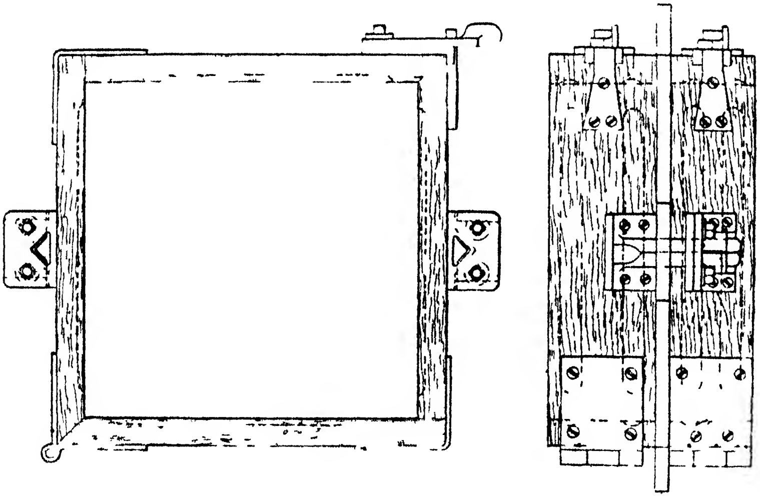


Fig. 156.

CHAPTER VIII.

ON ENGINE BEDS AND BASE-PLATES IN GENERAL.

Definition of a Bedplate.—Horizontal Engine Bed.—Methods of Moulding.—Way of Casting.—" Boxing Up " of Patterns.—By Two Methods.—Attachments of Bed.—Types of Bedplates.—Core boxes.—Bedplate for Overhanging Cylinder.—Pattern.—Core-box for Piston-rod Guide.—Other Boxes.—Pattern for Crane Bed.—Camber.

THERE is no limit to the forms which bedplates may assume. But however their details may vary, a bedplate is a bed-

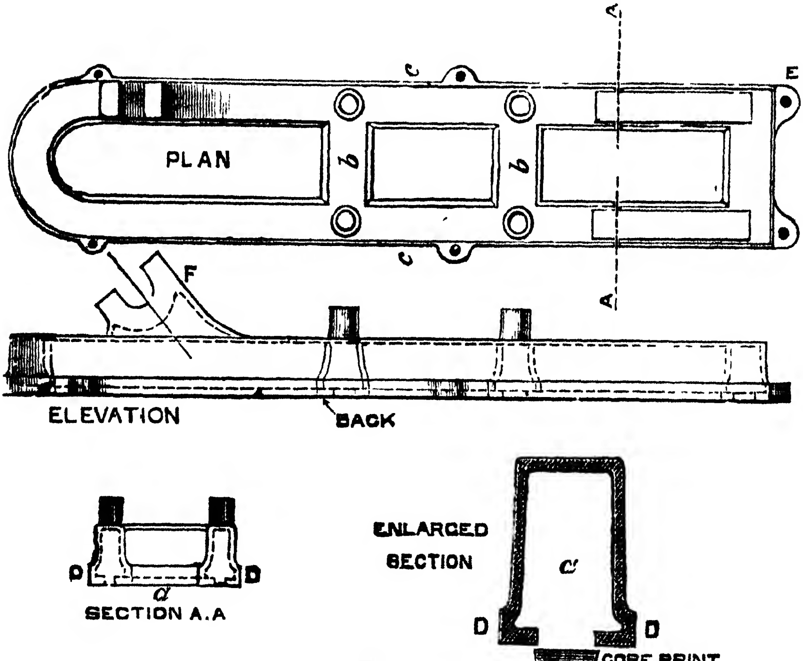


Fig. 157.

plate after all. Any piece of casting which becomes the foundation for machinery may be termed a bedplate or baseplate.

In a general way we should define it as a plate of metal rendered rigid by means of ribs or flanges. There may be bearings, brackets, facings, lugs, bosses, recesses, mouldings also, which will complicate the pattern in a greater or less degree; but the remarks following will apply in a general way to all castings of this class.

We will, first of all, give detailed directions for the making of a common type of engine bed, and afterwards pass on to observations of a more general scope. Say, then, we have to make a bedplate for an engine of the ordinary horizontal type. The bed is of a type which in these days of compact and cheap engines is becoming somewhat antiquated; but it is purposely chosen because it illustrates well the method of "boxing up," and affords a good medium for the remarks we wish to make on beds in general. It is a plain bed shown in Fig. 157. Two ways of constructing it would occur to the pattern-maker. One would be to make the pattern like the casting, allowing everything to deliver itself; the other would be to take out the space between the ribs with dried cores. Selecting a bed having a section like Fig. 158, the first method would answer very well; but taking one with a section like Fig. 157, the second plan would be preferable. Where the pattern delivers itself, the sides (Fig. 158, *a*, *a*) must be tapered, or set out of perpendicular, say ⅛ inch or ¼ inch, depending on the depth of the bed; and the flat ribs or flanges, *b*, *b*, must be held only temporarily with wires or "skewers," so that after the pattern is rammed up they may come away loosely along with the body of sand which forms the hollow portion of the bed, to be subsequently withdrawn sideways. But where the hollow portion is taken out with cores, as in Fig. 157, the pattern will be made just as though the casting were not to be hollowed out at all, and core prints on the back (enlarged section) will give the only indication that the bed is not intended to be solid. Let us premise that when we mention the back of a pattern we mean that portion in the top of the mould—in the case of our bed, that portion which bolts on the foundation-stone.

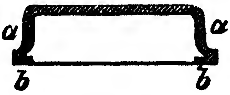


Fig. 158.

Now, it would always be more convenient to lay cores in the bottom part of a mould than to hang and screw them in the top. But as will be later mentioned, when speaking of cylinders, the bad metal always rises uppermost, and it would be highly detrimental both to the strength and appearance of a bedplate to have a quantity of scurf and air bubbles spread

over its surface, where facings, bearings, bosses, &c., require to be faced bright, and where a sound plate is necessary to sustain the complicated strains and stresses of moving parts. Hence it is usual to cast beds with the plate downwards, and to hang the cores in the top.

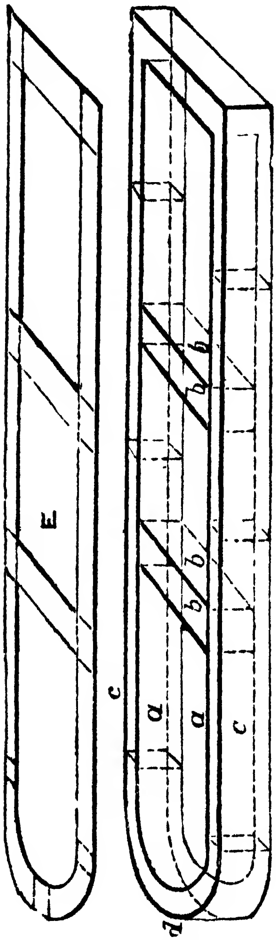


Fig. 159.

If we had to make a small bed-plate for a four or six H.P. engine, we should plane up solid stuff and mortise the crossbars (Fig. 157, *b*, *b*) into the sides, *c*, *c*, a process sufficiently simple to need no descriptive detail. But if the bed were a large one, say ten or twelve feet in length, we should "box it up." In illustration, suppose we had a plain rectangular piece to box up, 12 feet long, with a 9-inch by 6-inch cross section, and had 1-inch stuff available for the purpose, we should get out the two sides 9 inches wide, and the top and bottom each 4 inches wide by the 12 feet in length, drop the top and bottom between the sides, and nail together. Internal support would be given to the "box" by cross-bars or blocking pieces placed at intervals of about a foot. By building up pieces of heavy section in this manner a saving of timber is effected, and the liability of the pattern to warp and twist out of truth is lessened.

We can apply this method to our bed in one of two ways. The sides and cross-bars may be each boxed up separately—squared off to their respective lengths, and fastened together by tightly fitting dowels, assisted by screws driven in obliquely. The better method, however, is to frame the top and bottom plates of the pattern together with half-lap joints (Fig. 159). Then to take the pieces intended for the sides and screw them on separately through one plate, first remembering to screw the inner sides, *a*, *a*, of the bed to the ends of

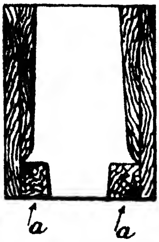
the cross ribs, *b*, *b*, *b*, *b*, before the outer sides, *c*, *c*, are put in place. The sweeped or curved end, *d*, may be built up with an outer and inner course of circular segments, or simply of circular arcs. Then, when the sides are all complete, place internal cross-bars, to insure the necessary rigidity during ramming up, and screw on the top plate, E.

Proceed to dress off all overlapping joints, and to mark out all centres. Dowel prints ½ inch or ¾ inch thick on the back to carry the lightening cores, for if screwed fast, the top sand, on being lifted, will be torn away; if dowelled they come up with the top, and can be taken out one by one. A moulding, D, D, will be carried round the lower edge of the casting; plane this to required shape in strips, and screw on. Round the semicircular end it will be "saw kerfed" after carpenters' fashion, or, if the machine is available, formed on the band-saw and then finished on the sanding machine. Lugs or ears for bolting down, E, will likewise be made, and screwed to the outside of the moulding. A bearing, F, will be cast on to carry the crank-shaft. It will be at an angle of 45° or thereabouts with the face of the bed, and will require to be drawn from the sand *parallel with its own centre line*. Therefore it will be dowelled, and left loosely in the mould. This also will be lightened with a core, and the recess for the reception of its brass bearing will be either taken out with a core or cut in the block, it is immaterial which. Bosses for the guide-bars are turned and pinned on. Facings for the cylinder will complete the bed.

It will be found that almost every type of bed casting can be produced by working more or less along the lines indicated in this chapter. Broadly, then, they may be divided into beds either solid or boxed up, and beds the counterparts in shape of the castings; in the latter case leaving their own cores, in the former hollowed by dry sand cores. In one or other of these methods, or by a combination of both, all bedplates can be made. In some classes of work drawbacks are useful; but as a chapter (VI.) is devoted to this and kindred subjects, we will not enter into it here.

The core-boxes remain. They are readily made. The sides, including the depth of the core together with its print, are grooved out for the reception of their ends. Flanges are dropped within the box like the internal flanges in the casting, but *thicker* than those by the added thickness of the *print* (Fig. 160, *a*, *a*). As the cores are sometimes of different lengths, though of the same section, one box is made to do duty for

them all, their various lengths being given by an adjustable sliding end, screwed where required. The lightening core in the bearing will require its special box, and will be adjusted by chaplets—a print on the bottom not being available; or it may be screwed through one of the long cores into the top. A special box may also be made for the semicircular end, or, if economy is to be studied, the end core may easily be strickled. All that is necessary then is a strickle about an inch thick, cut to the shape of the core section, and a thin cast plate of iron to strike and dry it upon.



SECTION OF CORE BOX
Fig. 160.

Figs. 161 and 162 illustrate an engine bed plate, with crosshead guide and crank bearing cast in one piece. The bed is for a cylinder of overhanging type. In the figures, A is the plate of the bed, B the sides, C the circular guide, D its oil cup, E the stuffing box for the cylinder, F the crank bearing, G lugs for bolting the bed down, H the fillet or beading. There are other minor parts besides, lettered in the figure, which will be referred to presently.

There is only one really practicable method of moulding this bed, and that is in the reverse way to that which it occupies when fitted up. Nearly all the outside portion will deliver freely. The facing J, however, which receives the cylinder flange, must be left loose. The bearing F must be dowelled on, to be drawn after the bed in a diagonal direction, that, namely, of its own centre line. The facings *a* must be skewered on, and the seating *b* for the brasses must be cored out. But the most troublesome portion is the circular guide C. There are three points about this guide that have to be considered. First, it is hollow; next, there are side openings *c c*; lastly, there is a portion *d d*, seen in Fig. 162 to be undercut. Without discussing possible methods of getting over these points in moulding, I will simply say that the only practicable way of doing so is to core out the hollow part, the side openings *c c*, and the undercut portion *d d*, in a single core. How this is done will be shown presently. At present I will consider the pattern work only.

Figs. 163 to 166 give various views of the pattern, made in the best fashion. First, it is boxed up. Top and bottom pieces of board A A are cut to the plan outline of the bed, and the sides B planed to parallel width, are fitted between, and the whole is nailed or screwed together. Those portions of the sides which are curved are sawn out with band saw, or cut with

gouge and chisel to the required curves. To avoid short grain, they are made in two or three separate lengths, and abut simply at the ends like the similarly curved portion of the fillets c, seen in plan. Taper is put in the sides. In a shallow bed like this, ⅛-inch on each side is ample. The lugs G are worked separately and screwed upon the fillets. Core prints *g*, for the holes that receive the hold-down bolts, are nailed upon the lugs.

The crank bearing F is cut to outline and dowelled on the

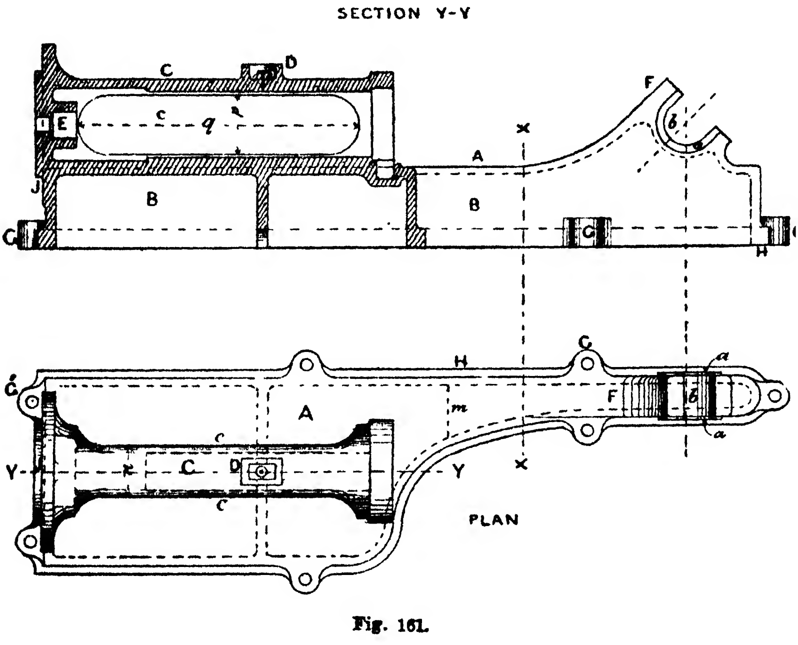


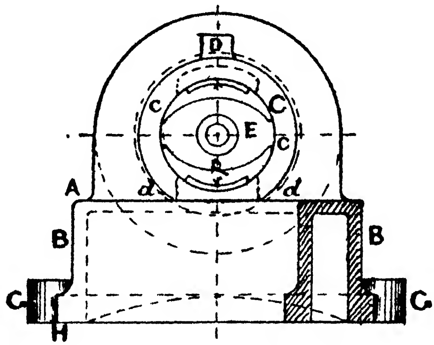
Fig. 161.

plate A. A deep bearing like this should be secured temporarily with cramps while being rammed in the sand. The dowels will keep it in central position, but will not be a security against its being rammed aside.

The print *f* carries the core for the recess *b* in Fig. 161 ; *a a* are the facings that receive the shoulders of the brasses. These facings are skewered on because they have to be left in the mould, to be withdrawn subsequently to the block F.

The guide C in Fig. 161. being cored out, is blocked up in the pattern in any convenient way. In Figs. 163, 164, and

165, the method shown, which, however, may be modified, is this: A block K, which may either be solid or boxed up, is screwed upon the plate A and cut to the outline of the upper half of the openings *c* in Fig. 161. Upon the block is fitted the pattern parts, cut to correspond with that outside portion of the curved guide C which stands above the print K. The way in which this is made is rendered clear by the timber shading. The flanged end L is cut "plank way," to avoid short grain. The facing J for the cylinder is a separate turned piece skewered on. The oil cup D is screwed as a separate piece upon the guide, and has a print *d*. The under-



SECTION X—X

Fig 162.

side of the bed is cored out, and M is the print. Being of large area, it is thin, ¾-inch only, and is dowelled on.

The core boxes for the bed, shown in Figs. 167 to 169, will now occupy our attention. The only intricate box in the lot is that which takes out the circular guide. This is shown in Fig. 167. The total length *k* of the core made in this box is the same as the length *k* of the print K in Fig. 163, and the width *k*′ as that *k* of the print K in Fig. 163. Its depth *k*″ is not important, but is sufficient to give room for a thickness of timber above the upper and hollow part of the crown of the guide. The box is made with bottom board D, sides E E, and ends F F, the latter rebated into the sides.

A rather close examination and comparison of the figures will be necessary to make clear the relationships between it

and the drawings of the bed casting, and of its pattern. The hollow part of the guide is formed of several sectional portions. Of these one moiety is put upon the bottom board; the other is carried with the battens *e e*, *m m*. The lower half of the parallel bored portion of the guide is formed by the piece *n*, the upper half by the piece *o*. The width of the pieces *n o* corresponds with the width *n* in Figs. 161 and 163 The diameter *p* of the bore corresponds with the diameter *p* in Fig. 161 with, of course, allowance for machining. The

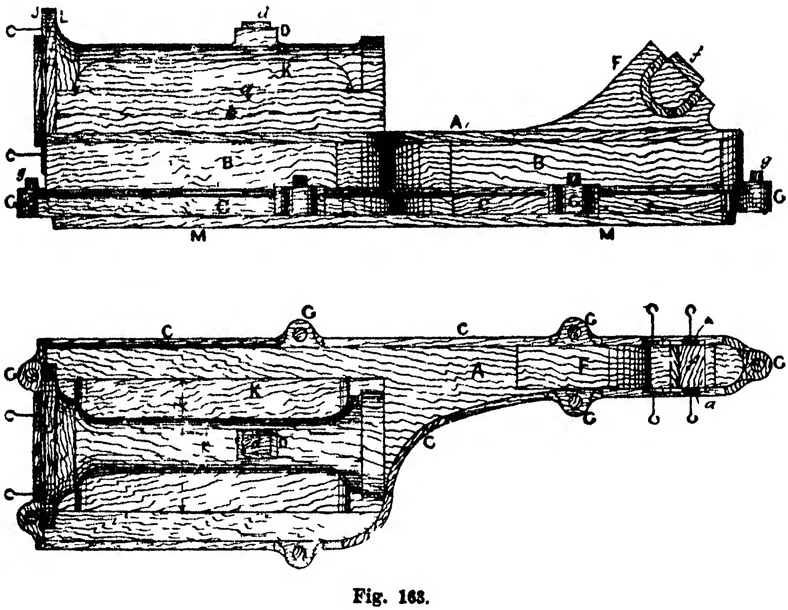
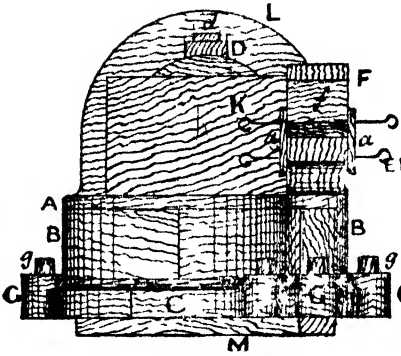


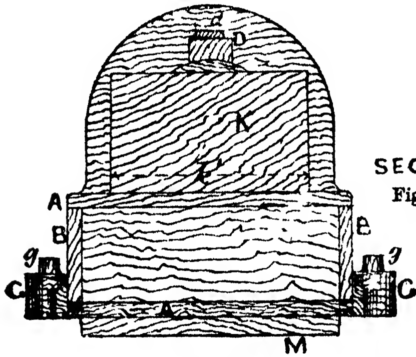
Fig. 168.

length *q* of the openings corresponds with the length *q* in Figs. 161 and 163. The length *r* in Fig. 167 terminates the parallel portion of the guide, and the pieces *n o* at top and bottom terminate there for convenience sake. Comparing the blocks *s*, *t*, *u*, and *v* with the corresponding parts of Figs 161 and 163, particularly the plan view in these figures, their coincidence will be more clear than any laboured verbal description can make them. In the plan view of Fig. 167 the top blocks *u v* are removed, so that we are looking into the lower half of the box on the line x—x. The upper half *o* of the straight portion of the guide, with its battens *m m*, is, however, left in



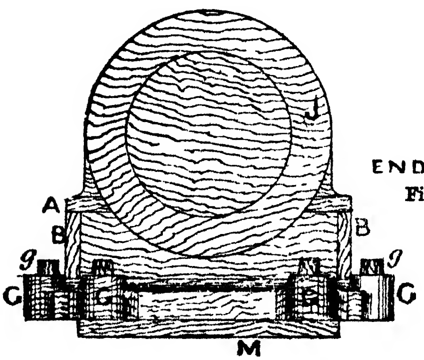
END VIEW
Fig. 163

Fig 164.



SECTION
Fig. 163

Fig. 165.



END VIEW
Fig. 163.

Fig. 166.

position. One of the upper blocks *v*, removed, is seen at the top right-hand corner. At *w* is seen the stuffing box, shown

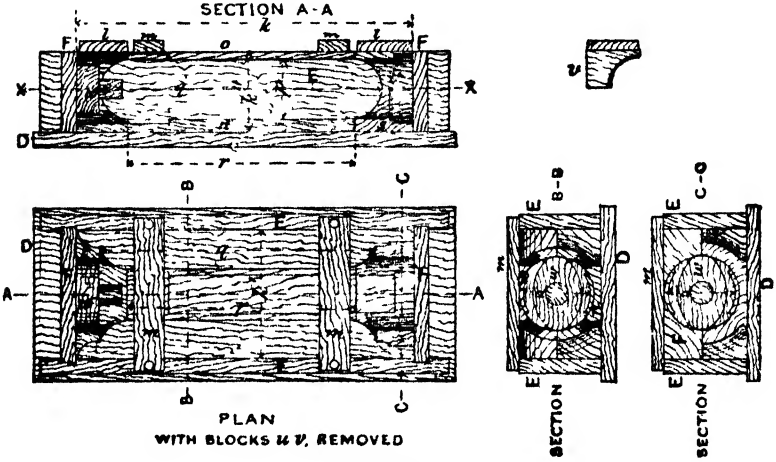


Fig. 167.

at E in Fig. 161. It is provided with a print for coring out the stuffing box, which core is inserted in the main guide core. When this guide core is made and placed in the mould, it not

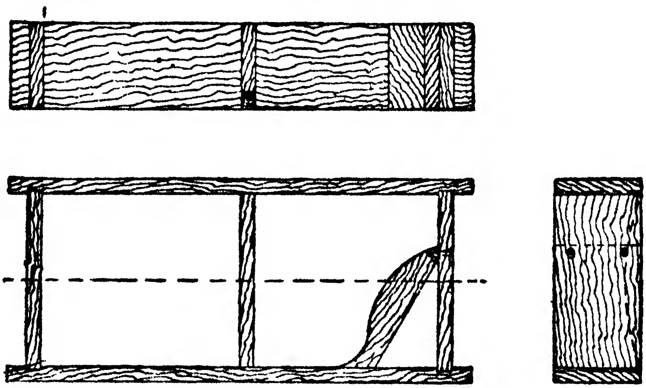


Fig. 168.

only fills up the print K in Figs. 163, 164, and 165, but also takes out the whole of the circular portion of the guide, the side opening *c c*, and the undercut portions *d d* in Fig. 162.

The remainder of the core-box work is simple. Figs. 168 and 169 show the boxes used for coring out the underside of the bed. The cores are parted at the line *m* in Fig. 161, and their correspondence with the outlines seen dotted in plan and in section in Fig. 161 is so obvious as to need no comment. Sometimes the main core is made of the full length, and the lightening core for the bearing made separately; but this is of no consequence. I am showing these just as they occur in the example from which they are taken.

Pattern for a Crane Bed.—Fig. 170 is a centre bed for a crane that rests upon longitudinal girders by the narrow

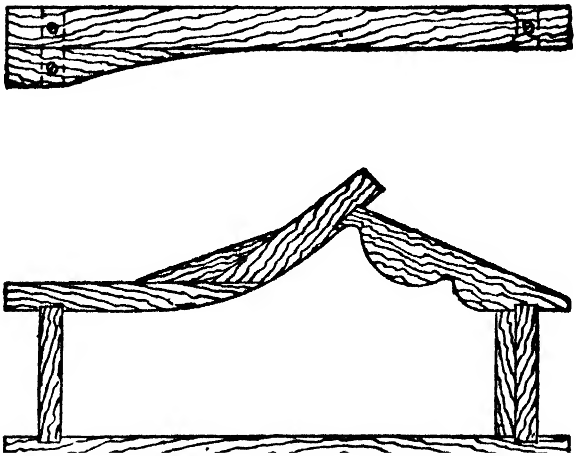


Fig. 169.

strips *a, a*, and the bolts which retain it in place pass through the sides B, B. As a general rule beds which are double flanged like Fig. 170 are cored out, the conditions being different from those which exist in the beds which have no flanges in the bottom, and which can therefore deliver themselves. Still, beds like Fig. 170 can be made to deliver readily if the bottom set of flanges is left loose. Then no core-boxes would be necessary; the cores would be rammed in place within the pattern on grids, and lifted out after the withdrawal of the upper portion of the pattern, which would be jointed as shown at *a, a* (Fig. 171) leaving the bottom flange exposed for withdrawal finally.

Though entirely practicable, there is not much advantage in the adoption of this method. The one advantage is the saving of the cost of drying cores and the slightly increased expense of making dried sand cores over those which are rammed in place in green sand. As a set-off there are these great disadvantages—that the full pattern costs more to make in the first place than a skeleton pattern and core-boxes, and that alterations are much more readily accomplished in the latter than in the former. Unless some alterations are permitted

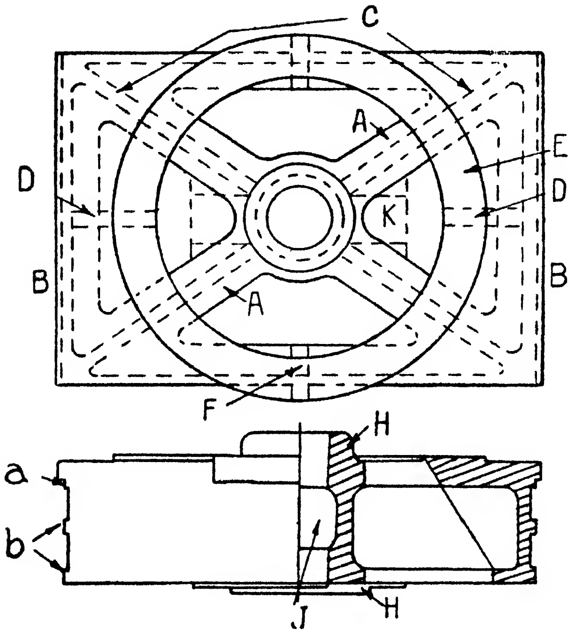


Fig. 170.

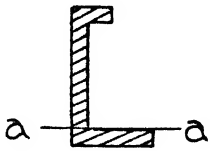


Fig. 171.

to be made in such patterns, the number of the patterns required in a shop increases beyond storage room. It is very easy to lengthen or narrow skeleton pattern frames and their core-boxes to suit beds of different lengths and widths. The depth also can be increased readily. Neither of these differences can be made in a full pattern without a good deal of cutting about, amounting in some cases to nearly making the pattern afresh. In the main, therefore, examples like Fig. 170 are better cored out than made as full patterns with the bottom flange loose.

At one time several wasters were made by the endeavour to plate over the castings of the type in Fig. 170, both on top and bottom, leaving only a few 4-inch or 6-inch holes for the removal of the core. The shrinkage stresses operating on the large areas of metal broke them. Experience has proved that they may be safely plated on one side—the top, but not on the bottom as well. But the form shown in Fig. 170 is one which is perfectly safe if well proportioned, as shown, and cooled regularly, provided the central boss is not excessively heavy.

References will be necessary in order to connect the details of the pattern work with the casting here shown.

In Fig. 170, A, A′ are the top and bottom webs or plates, lightened out to give the forms of the diagonal arms shown. B, B are the sides which fit within the truck frames, each being provided with a bearing strip *a* and planing strips *b*, *b*, to diminish the area to be tooled. C, C are the main diagonal ribs, D, D small stiffening ribs, E is the facing for the curb ring, F extra metal to support the circular facing where it projects beyond the sides of the bed casting, G, H boss portions, J centre hole, and K, K dotted outlines of facings required for travelling brackets when the casting is used for a portable crane. If for a fixed crane only, no such facings are required.

Centre beds of this class are moulded over a cinder bed. There is therefore no turning-over done, but bedding-in only. But the bedding-in is not exactly that usually understood—that is, the pattern is not hammered down into a hole dug in the floor, the sand being made good in detail under and around it. The pattern is laid upon a prepared bed, and the sand is rammed against its sides. Drawback plates may or may not be used to carry the sand at the sides.

The bed is conveniently prepared for the pattern by sweeping it off with a striking board. This is useful, not only because it permits of the even ramming and venting of a bed perfectly level, but also because the curb ring facing and the central boss with its print can be swept up by it.

A striking centre is first laid down in the sand above the cinder bed, to receive the bar and strap which are used for the striking boards employed for the various pattern beds. This is shown in Fig. 172, in which A is a casting with a broad base, bored to receive the turned end of the square bar B, upon which the strap C is slid up or down for adjustment, and pinched with

a set screw. Fig. 173 illustrates the striking board which is bolted to the strap, and which strikes up a level bed, with the projecting portion of the central boss H and its core print, and the facing E for the reception of the curb ring.

There are two ways in which the pattern can be made: one shown in Fig. 174, the other in Fig. 175. The first is a

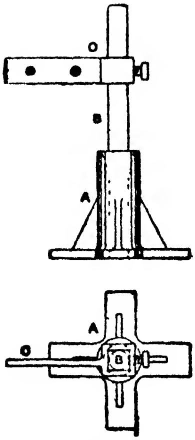


Fig 172.

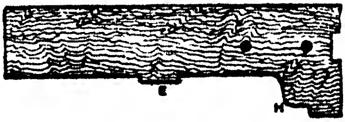


Fig. 173.

cheap method suitable for an occasional and odd casting; the second is better adapted for standard and repeated service.

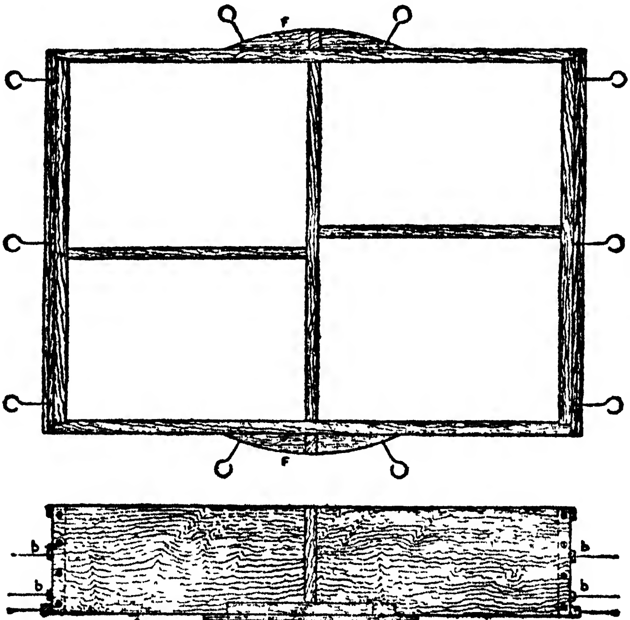


Fig. 174.

The first is a mere skeleton framing, formed of sides, ends, and cross-bars screwed together, without bosses or ring facing, excepting those portions of the latter which overhang the sides at F, F, corresponding with F, F in Fig. 170. The face A is cast downwards, and the strips at the end are skewered loosely. In the second (Fig. 175) the framing is boarded over on both top and bottom, with open joints, indicated by the blacker lines. The boards are recessed into rebates planed in the sides

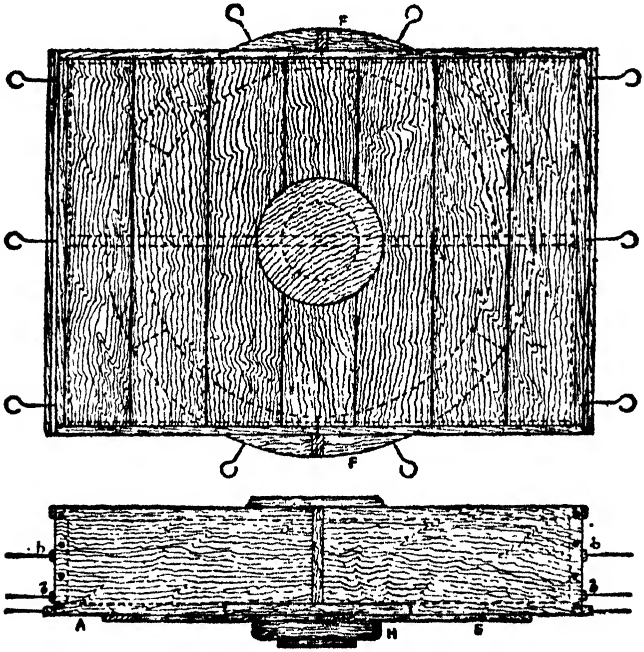


Fig. 175.

and ends. The whole of the ring facing E is screwed on, and the bottom boss H also. The striking board in Fig. 173 is used for sweeping up the bed in both cases, necessarily in Fig. 174, and for convenience in Fig. 175, because it would be troublesome to bed-in so broad faced a pattern.

Figs. 176 and 177 illustrate the core-boxes. A comparison of them with the casting in Fig. 170 will render their relations clear. Top and bottom framings, which give the flange thicknesses and outlines, are dowelled on the main framings, which form the internal faces of the sides, ends, diagonal ribs,

and central boss. The cores are set in the mould by measurement without prints. The central core is struck against a board.

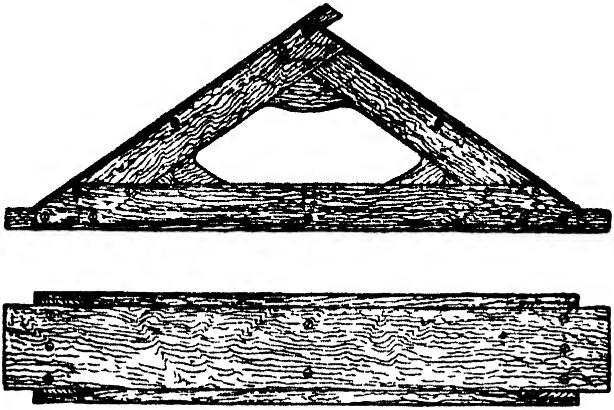


Fig. 176.

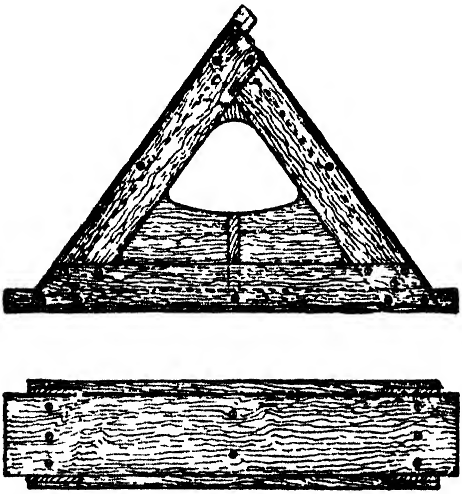


Fig. 177.

Camber.—Camber or curving or buckling in castings is of much importance. If there were no shrinkage in metal there would be no curving in cooling, and therefore no camber

required in the patterns. Many castings do not curve because the cooling takes place regularly, and the useful guide in these things is that afforded by the constant habit of observation and a long experience. The engine bed in Fig. 157, p. 108, will certainly curve in cooling, so that if the pattern were made straight the plated portion of the casting would be concave when cold. To what extent it would curve it would be impossible to say without previous experience. It may be $\frac{1}{4}$-inch, $\frac{3}{8}$-inch, or $\frac{1}{2}$-inch, according as the moulding and inner rib are thick enough to compensate in a greater or less degree for the larger extent of metal in the top plate. We therefore *round* the pattern to the same extent that we expect the casting to go *hollow*, and in the *opposite* direction.

Yet, although a long narrow bed will curve to a considerable extent, a broad plate made double for a pair of engines will be found to remain very much like the pattern. And the rule appears to hold good that the narrower the casting the more liable it is to warp. Breadth apparently gives rigidity, since on a long narrow casting a very slight excess of metal will cause a curve in the direction of that excess, while on a broad casting it would have no ill effect. Other conditions being equal also, a light casting will always "go" more than a heavy one, and will be influenced by slight modifications that would not affect the heavier one. The quality of metal, too, is not without its influence, hard iron being more liable to curve than the softer kinds. Every now and again, however, things crop up in foundry practice which appear to invalidate one's pet theories on this subject.

If the shrinkage is uniform everywhere the cooling will be regular. If not, curving, if tied to prevent that, will occur or fracture may result. Whenever a considerable disparity exists in adjacent sections, curving or drawing will occur, or internal tension will be set up, or fracture will happen. These facts are excellently illustrated by the arms, rim, and bosses of pulleys. The effects of unequal shrinkage may be masked by the effects of cooling on the crystallisation of iron. Rapid cooling yields small crystals, slow cooling large coarse crystals. The largest crystals are always found in the central portions of castings in which the cooling has happened slowly. In consequence of this, metal has a large power of accommodation during its cooling to the external influences tending to cool it rapidly. When the cooling about the

centre is so prolonged that the crystals become torn apart by the inertia of the colder external metal, then the central portions either become extremely open, or they segregate, producing a draw or open space, or they become torn apart. But before these things happen the power of accommodation of the central portions remains in force, coercing in greater or less degree the movements of the parts which have already become cooler. These facts must be borne in mind, and they

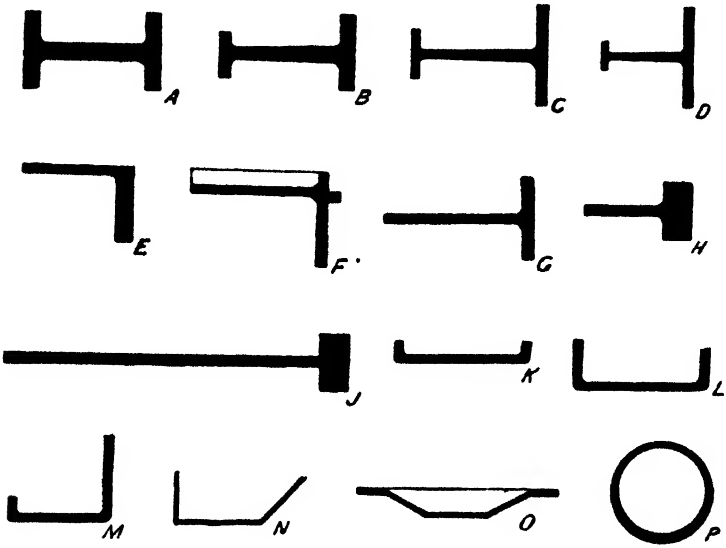


Fig. 178.

help to explain the apparent contradictions which one meets with in the curving of castings. The section A, Fig. 178, will not curve in cooling, all the sections from B to H will, J will not, K to P will curve, but in different ways and degrees.

The section A will not curve in any direction, no matter what thicknesses are given to the flanges, because both are alike and the web occupies a central position. All parts will cool down uniformly. In B, C, and D the web and the thin flange will have cooled down and shrunk while the thick flange remains red hot, and the thick flange will, during a short season, become convex on its outer face. But when cold its outer face will become and remain concave. The

explanation is this: the heavy flange was drawn in the first place by the shrinkage of the light flange and web. But in consequence of its much larger mass of metal it afterwards, as it shrunk, pulled the web and light flange back in shrinking to its full amount. In doing so it acts as a carrier of heat to the lighter parts, and so prevents them from becoming so cold as to render them unable to respond to the shrinkage strains imposed upon them by their more powerful neighbour. They do not therefore shrink to their full capacity, while the heavy flange does.

But this cannot be put into a formula, because the degree of proportion counts for so much. C and D will curve much more than B will. And if B were a short girder its amount of camber would be nil or nearly so. C and D would camber even though short. Amounts might vary from $\frac{1}{8}$ inch to $\frac{3}{4}$ inch. The pattern-maker, therefore, has to consider *relative* proportions both of sectional areas and of length, and then use his judgment as developed by experience. There is no other way. I, in common with others, have sometimes formed an opinion of the amount of camber required in a pattern, and put it in and then have had to remove it altogether, or to lessen or sometimes to increase its amount.

These castings will only camber in one direction, in the plane of the flange faces. In some shapes curving will occur in two directions. Thus the outer face of the thick flange in E will be concave, as will that of F. In the other direction the web of E will usually remain straight, but that of F will be concave on the upper face. The influence of width on proportions is very great. G would become slightly concave on the face of the flange, H very much so, J not at all. The differences are due to the widths of the webs. The wider the web the better able is it to resist the influence of the cooling flange. When very wide its coercion is absolute even though the flange be very thick.

The stiffening effects of flanges in other shapes is illustrated. The tendency in K is to camber concave on the plain face of the web due to the large area of metal there. In L the tendency is lessened because the deeper flanges act as a corrective. The thicker the plated portion the greater is the tendency to camber. M is a section which will camber hollow on both of the broad faces. A gutter section N becomes concave on the bottom outer face. A section like O for a

penstock door or a buckled plate cools convex on the flat face, being pulled by the larger area of solid metal below it.

In all these cases we see that the presence of excess of metal is the condition which produces the concavity of face. In pipe and column work the opposite condition holds. Thus the section P if cast horizontally will cool concave along the thinner metal. The reason seems to be that little transmission of heat can take place, and therefore the thinner metal cooling off first, holds the thicker in bondage. Even if the thin metal is in the bottom of the mould the concave camber is still on the thin side.

The best-laid calculations of the pattern-maker may be largely invalidated by the moulder. Like results will only result when like conditions are observed. A moulder will often uncover a casting before it is cold. Then the uncovered part, cooling rapidly, will shrink more rapidly than the lower parts, which are not uncovered. A harder grade of iron will shrink more than a softer greyer kind. The moulder may, therefore, help to secure uniform results, or he may prevent their attainment.

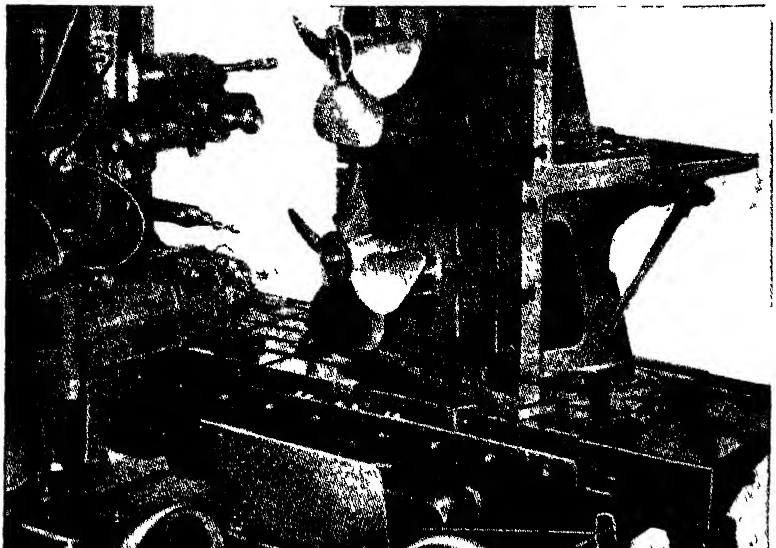


Fig. 178A.

This is the "Keller" Universal Machine, which is fitted with a unique electric copying device enabling metal patterns to be duplicated with absolute fidelity. Here the upper propeller casting is being copied. *Courtesy, Geo. H. Alexander Machinery Co. Ltd., Birmingham.*

CHAPTER IX.

ENGINE CYLINDERS.

Striking out.—Views required.—"Lagging up."—Head Metal.—Turning.—Passage Block.—Steam Chest Flange.—Prints.—Exhaust.—Feet.—Passage Core-box.—Exhaust Core-box.—Double Cylinder.—Pattern.—Board for Body Core.—Steam Chest Core-box.—Passage Core-box.—Exhaust ditto.—Steam Inlet ditto.

ENGINE cylinders are of all sizes—from 2 or 3 inches to 8 or 9 feet in bore, and of most varied types. The smaller ones are cast from patterns, the larger from loam moulds. We will take a simple illustration of a high-pressure cylinder of moderate size, and describe the making of its pattern before we pass on to the loam cylinders. This, like most of our work, must be struck out on the drawing-board. We want a longitudinal section, cutting through the steam ports and valve face (Fig. 179), and a transverse section through the same face and the exhaust port (Fig. 180), also a plan of the cylinder looking into the ports (Fig. 181). Make the drawing to the sizes of the finished casting, adding the due allowance afterwards for turning and boring. Taking a cylinder of 6-inch bore and 10-inch stroke, we give it certain definite proportions for convenience of illustration.

	in.
Length of cylinder	$14\frac{1}{2}$
Thickness of metal in body	$\frac{9}{16}$
,, flanges	$\frac{3}{4}$
Length of port	$3\frac{1}{2}$
Width ,,	$\frac{7}{16}$
,, exhaust	$1\frac{1}{16}$
Metal round ports	$\frac{9}{16}$
Length of valve face	7
Width ,, ,,	$4\frac{3}{4}$
Length of steam-chest flange	10
Width ,, ,,	$7\frac{1}{8}$
Thickness of ditto	$\frac{5}{8}$
Distance between ports	$\frac{5}{8}$

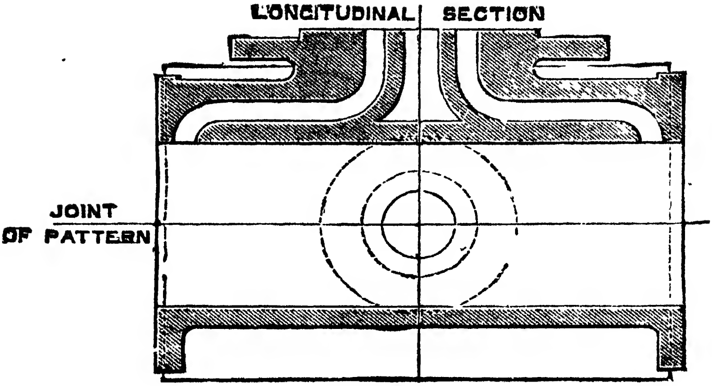


Fig. 179.

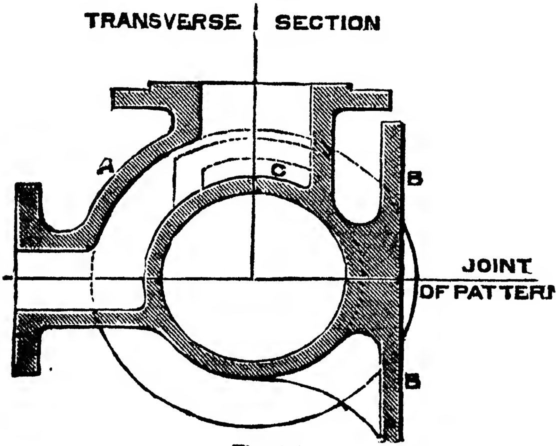
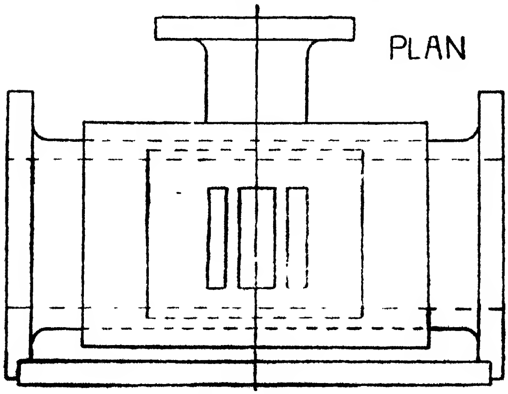


Fig. 180.



K

Fig. 181.

A foot or a pair of feet will be required for the purpose of bolting the cylinder on to its bedplate or framing, and their shape and position will be determined by the shape and position of the part to which they are to be attached.

When about to make the pattern, commence with the circular body. In order to mould well, this must be jointed longitudinally with dowels; and unless a piece of very dry timber is available, it is not customary or wise in a standard pattern to make it in the solid. The proper way to make cylinders, as well as large pipes, is to "*lag them up*." Longitudinal strips are glued and secured with nails or screws to transverse ends which have been planed hexagon, octagon, or polygonal in form, the size across the flats being determined by the thickness of the stuff in the *lagging*. Dowel the end blocks in their joints, mark out into flats, and saw and plane perfectly square across the thickness of the stuff (Fig. 182, section).

Now lay the joints of those halves which contain the dowel *holes* on the bench or on a true joint board, at the distance over all which coincides with the extreme ends of the pattern. In this instance this will be 14½ inches = length of cylinder + say 3 inches at each end for prints + 2 inches for "head metal" = in all to 22½ inches, and this will be the length of the lagging also. The object of head is this:—When metal is poured into a mould, dirt and scurf, being light, float on the surface, and along with entangled air bubbles rise to the top, making the upper part of a casting spongy and unsound. In an engine cylinder this porosity would be a fatal evil, diminishing its strength and permitting escape of steam. So these lighter matters are allowed to float into a ring of "head metal" of the same diameter as the cylinder, and of sufficient height to contain them all. It is scarcely necessary to remark that this is turned off the casting and thrown away.

Sometimes the pattern proper finishes with the head metal, and the prints are turned separately and screwed on the ends. This is a matter of no importance; but if our stuff is long enough to turn prints as well as body (and we will suppose this to be the case) our angular transverse ends will occupy the "out and out" position. Now take one of the pieces of lagging, plane up the face quite true, and bevel both edges. The width on the face will be the same as the flats on the transverse ends, and both edges will be bevelled so that if projected they would meet at the central axis of the cylinder. Glue and screw this first piece in place with one edge resting

on the joint board or bench; chalk its upper edge, and fit the second piece against it, until the chalk shows a fit everywhere; plane the next edge to the same bevel at the proper width, and then glue both the face and the chalked joint, and screw. In this way carry the lagging round the first half of the pattern. Now turn over this first half, lay the dowel ends in place, and build up the second half in the same fashion. Allow the glue time to set hard, and then chuck in the lathe with centre plates, which are simply square pieces of sheet iron or brass with screwholes at the corners, and made—one of them to receive the lathe-fork, the other counter-sunk to run on the back centre (see Figs. 69, 70, pages 43, 44). When screwed in place, they form the temporary centres of the pattern, and retain the two halves securely together while being turned. The screws which hold them on should be put in firmly in order to prevent the work flying asunder while in rapid rotation.

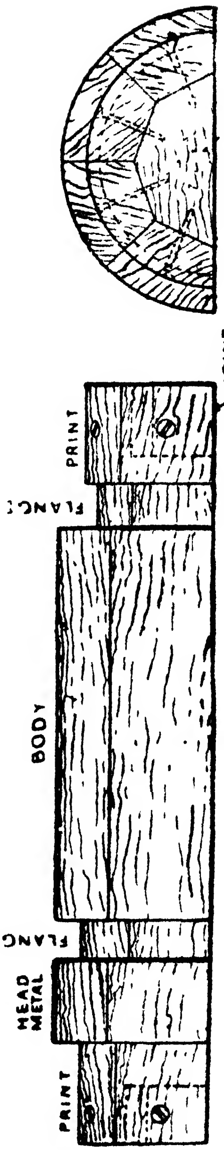


Fig. 182

Now, having our cylinder in the lathe, and being assured that everything is well secured, rough it down to within $\frac{1}{8}$ inch of the body size with a sharp gouge. If belts are desired, the pattern must be roughed to the size of the belts first, and afterwards turned between the belts to the body size. Finish the body by scraping with a firmer-chisel. Mark on the body so turned a

line at the distance of one print from either end, equal to 3 inches, then another line at a distance from the first equal to the length of cylinder, + the allowance for facing on flanges, — ⅛ inch. on each flange, equal to 14¾ inches in all. From these two lines strike two others equal to the thickness of the flanges with their hollows, allowing, say, ⅛ inch for hollow. Turn out grooves for the flanges in the spaces thus marked; measure off 2 inches, the length of the head metal, and that will leave 3 inches for the length of the second print. Turn these prints down to 5¾ inches diameter, parallel, no taper being required—the cylinder moulding on its side; 5¾ inches diameter will give the proper allowance for boring out on a small cylinder, but in larger ones we should have rather more, from $\frac{6}{16}$ inch to $\frac{7}{16}$ inch. Glass-paper and varnish the body, take it from the lathe, and remove the centre plates. Fig. 182 will represent one half the pattern at this stage. Turn the flanges in halves on the face-plate to fit the grooves, not forgetting the additional ⅛ inch in thickness for facing. They may be screwed on the body or left loose—it is of no consequence which.

The ports and valve face will claim our next attention. Get a block of wood, wide enough and thick enough to include the ports and the metal inclosing them, and fit it between the

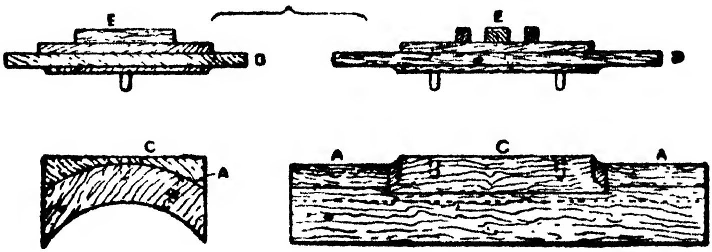


Fig. 183.

flanges and round the curve of the cylinder body (Fig. 183). Having hollowed the inner face, plane the outside convex and concentric with the cylinder body (Fig. 183, A), making the thickness equal to the width of port and of the metal bounding it (Fig. 183, B). Recess this across the centre to receive the block through which the ports curve upwards into the valve face (Fig. 183, C). This last piece should extend as far as the termination of the hollow on the under side of the steam-chest flange. Be careful to have the top of this block

parallel with the joint of the pattern. Laying the half pattern on a true board, rest a straightedge over the block, and, measuring near its extremities, adjust its edge until it shows the block parallel with the board. Then screw in place. Next, prepare the flange for the attachment of the steam-chest (Fig. 183, D). Make it sufficiently thick to allow for facing, and also for working the hollow on its under side; dowel it on the port block, keeping it parallel up and down the cylinder. Work out the hollow on the back by hand or pattern miller (see Fig. 549); make the valve face and nail it on, and on that again nail, screw, or dowel the prints for ports and exhaust (Fig. 183, E). Leave these prints barely ⅛ inch narrower than the finished ports, so that the fitter may chip and file their edges accurately for the cut-off of the steam.

Now fit a block of wood for the exhaust, the D-shaped piece of pipe which comes from underneath the steam-chest flange downwards to the joint of the pattern (Fig. 180, A). Work the portion which fits the body of the pattern with a gouge, and the outer part with a chisel, using a templet struck semicircular in shape (Fig. 184). A distinct half-round block will be fitted on the other half of the cylinder body, forming a continuation and termination of the D-shaped pipe (Fig. 184, A). Make the exhaust flange and print in halves, and screw one half on each portion of the exhaust pipe, the joint of the flange coinciding with the joint of the pattern (Fig. 184, B, B).

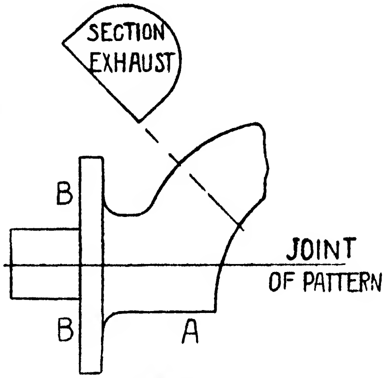


Fig. 184.

The feet in our pattern are at right-angles with the steam-chest face (Fig. 180), and can be fastened on permanently to draw with the pattern; but had they been on the side opposite to the valve face, they and their bracketings must have been held in place with temporary screws only, put in from the inside of the lagging. Put hollows behind these feet, and allow for planing on their faces, B, B.

We now consider the core-boxes. They are two in number, the steam passage and the exhaust. No box is requisite for the centre core, for the core maker strikes that against the

edge of a loam board. In this case it is simply a board a few inches longer than the cylinder and prints, having one edge planed straight and *chamfered.* The core-boxes, however, are not easily made by an inexperienced hand. By adhering to the following directions, and exercising a little "insight," no great difficulty need be experienced :—

Take the passage box first (Fig. 185). We have the curved part drawn in section (Fig. 180, c, and Fig. 179). Prepare, therefore, two pieces of wood, just the width of the port $=3\frac{1}{2}$ inches, and exceeding its extreme length by about

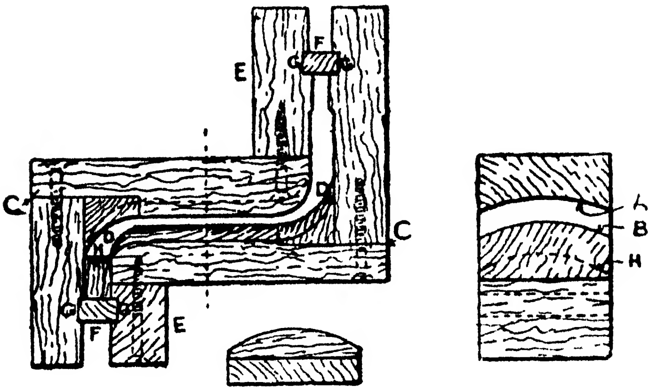


Fig 185

4 inches, and sufficiently thick to allow of planing out the curves, and giving an inch of wood in the thinnest part besides. For the outer curve of the port (Fig. 185, A) *hollow* one of the pieces, using a templet struck from the drawing, and for the inner curve *round* the other piece (Fig. 185, B).

We now want to form the ends and their curves. Evidently the longitudinal central lines of the pieces just worked correspond with the port lines on the longitudinal section we have drawn upon our board. So we set the *central* line of each piece in turn over its corresponding line on the board, using a set-square for the purpose, and we see at a glance that we must block up at the ends of our straight pieces in order to form the terminations of the box, and we also see the amount of blocking that is necessary. Rebate out across the curved faces for the reception of these blocks, and glue and screw them in

place, C, C. Fit and glue in like manner the bits which are to form the hollows, D, D, and work them in place. Screw on the blocks, E, E; connect the two portions of core-box with transverse ends, F, F, letting them into shallow grooves, G, G, G, G, in the usual way, to prevent their ramming out of position. It will be remembered that our prints were made narrower than the finished ports to allow for exact adjustment of the valve. In that end of the core box, which corresponds with the print, thin strips of wood will be glued to diminish the opening to the width of the print. These strips may be ½ inch wider than the thickness of the print, giving ½ inch for depth of chipping strip in the casting. The planing will take

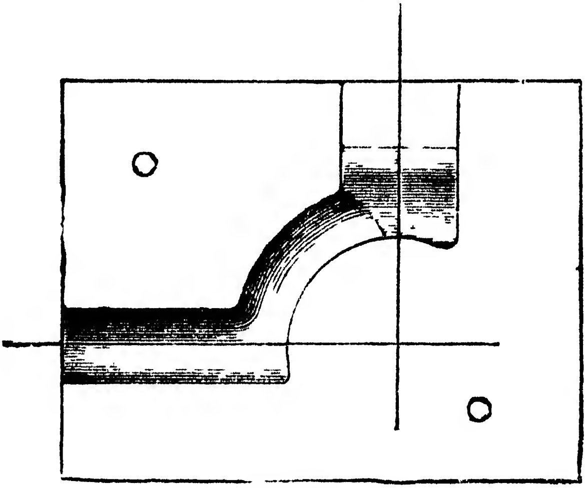


Fig. 186.

¼ inch out of this, and the wear of the valve will reduce its thickness further in course of time.

The other end of the core will fit the body core of the cylinder, and must, therefore, be hollowed to that curve. Fit a piece in that end, and with its rounding face H towards the *core space*; this will impart to the core the hollow form required.

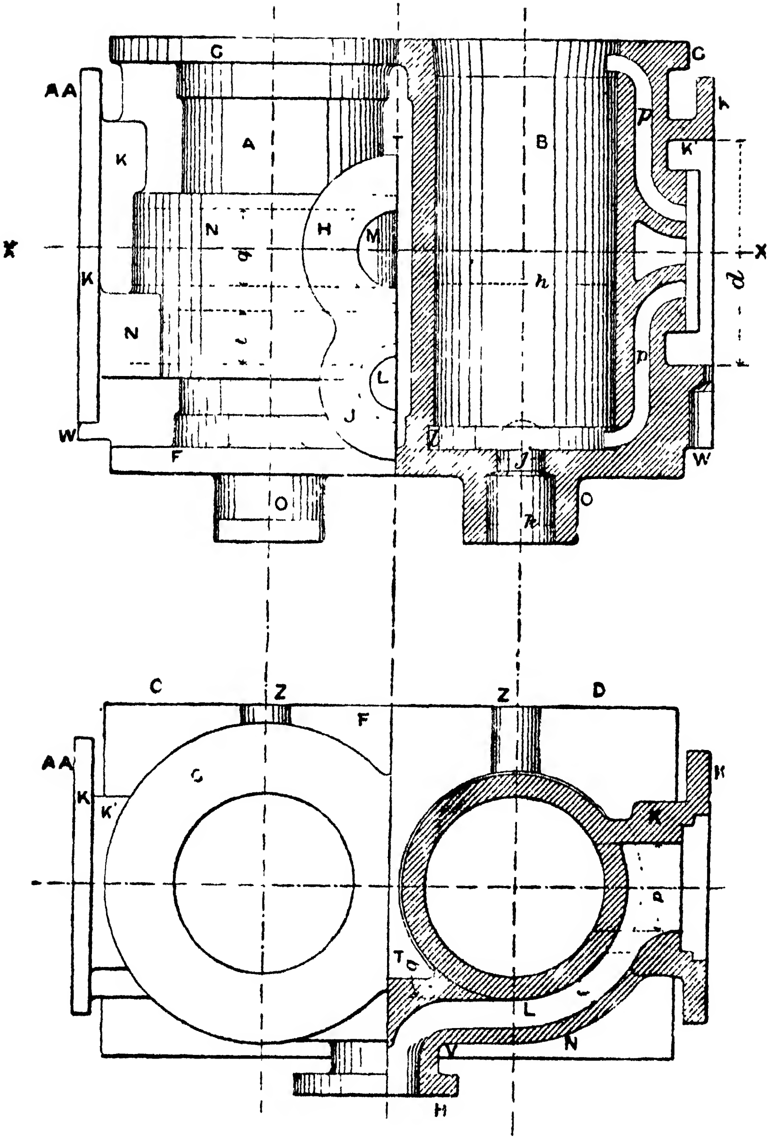
Lastly, there is the exhaust (Fig. 180, A). The joint of this box will correspond with the transverse section of the cylinder, cutting the exhaust passage along the centre. Two pieces of wood are required, sufficiently long and wide to include the whole course of the exhaust with its prints, with about a couple of inches of timber besides (Fig. 186). They should be about an

inch thicker than the semidiameter of the passage. Face both pieces truly, dowel together, and square one side and one end. To these corresponding faces transfer, by means of square and compasses, the sectional view of the exhaust port from the drawing board, extending that view to include the prints. The ends of the prints will coincide with the side and end we have squared. Gauge half the depth of the oblong portion of the port on each half of the box, and similarly strike on each half the circular portion of the port. Cut inwards with chisel and gouge, using templets to insure accuracy away from the immediate vicinity of the ends. Be careful that the halves of the box correspond, so that the core shall show no overlapping edges in the joint, and fasten the chipping strips against the valve face as in the inlet core-box. Fig. 186 shows one half of this box thus worked out.

This is an example of a simple type of cylinder. The following one involves a good deal more work.

Figs. 187, 188, 189 illustrate the casting of a double cylinder used for a pair of high-pressure inverted-cylinder engines of good type, and selected as a good example of neat pattern construction, and study in cored work. Fig. 187 is an outside elevation, A, and sectional elevation, B, of the cylinder. Fig. 188 is a plan, C, and a cross-section, D, the latter taken on the line X—X in Fig. 187. Fig. 189 is an elevation looking against the face, A A, of Fig. 187. In these figures the principal parts are as follows :—F is a square flange, by which the cylinders are bolted to the engine standards ; G G are circular flanges, which receive the top covers ; H is the exhaust flange, J the steam-inlet flange ; K K are the steam-chest flanges, K′K′ the steam-chests ; L is the steam inlet, M the exhaust outlet ; N is the block through which the steam and exhaust passages pass from L and M to the steam-chest in Fig. 189, N gives metal round the steam passages just where they enter into the steam-chest ; O O are stuffing-boxes for the piston-rod glands. Other minor parts which are lettered will be noted when describing the pattern and core-boxes.

Figs. 190 to 193 give different views of the pattern. Fig. 190 is an outside elevation, corresponding with the similar elevation of the casting A in Fig. 187. Fig. 191, left hand, is an outside view looking against the flange G in Fig. 188, and the right hand is a section taken on the line X—X in Fig. 190. Fig. 192 is taken against the steam-chest face A A in Figs. 187—189, and Fig. 193 is a view of the *joint-face* of one-half the pattern, to show clearly the way in which it is constructed.



Figs. 187, 188

The cylinder bodies, A and B in the figures, are made by lagging up. This is shown in Fig. 191 in end view, and in section. Transverse blocks, *a*, *b* (compare Figs. 191 and 193) are dowelled together, and the lagging strips *c* are fitted upon these with the edges jointed radially, and glued. The strips are made long enough to include the head metal, P, and the prints Q for the cylinder bores. Grooves are turned to receive the double flange G (compare with Figs. 187—189). These grooves are seen in Fig. 193. At the other end the bodies are

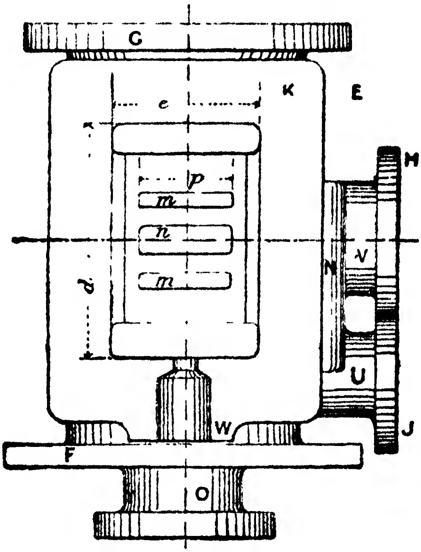


Fig. 189.

secured by means of the oblong flange F, screwed against the ends of the bodies. Upon this flange the stuffing-boxes O are screwed, with gland-shaped flanges and prints, R.

Upon the bodies the steam-chests and their flanges are now fitted. K′ is the body, K the flange. The body blocks are fitted round the curves of the cylinders, and the flanges screwed against them. Prints, S, are screwed against the flanges to carry the steam-chest cores, of length and width *d* and *e* respectively, corresponding with *d* and *e* in Figs. 187 and 189. These prints must be made wide, as shown, in order that the cores shall not overbalance themselves.

The block N for the steam passages will be the next fitting. It reaches across, and partly encircles, the two cylinder bodies, and is of the thickness *f*, corresponding with the thickness *f* of passage and metal in Fig. 188. A narrow piece, N′, is

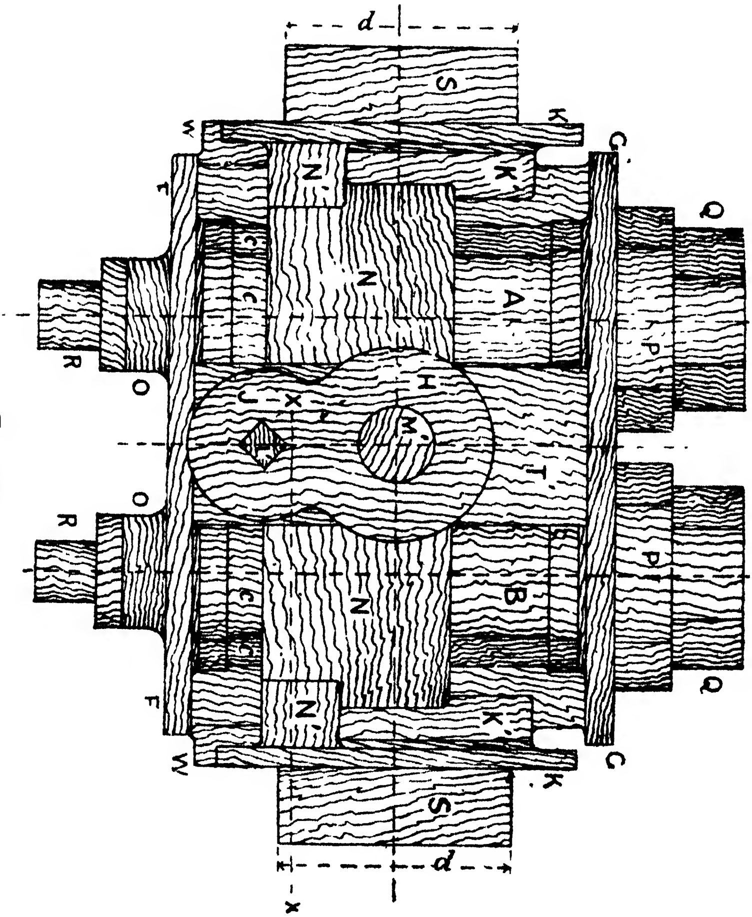


Fig. 190.

added at each end where the steam-passage core enters the steam-chest. Since there is an open space, T, between the cylinders (Fig. 188), it is clear that the sand forming that space in the mould would not deliver above the area covered by the block N. The only alternatives, therefore, are either

to put solid metal there, or to core out the space. To put a lump of solid metal there would be a barbarous alternative, and, besides looking unsightly, would cause a "draw" in the casting. Coring is easily done. The print for the core is shown at T′ in Figs. 190 and 191. It is fitted between the

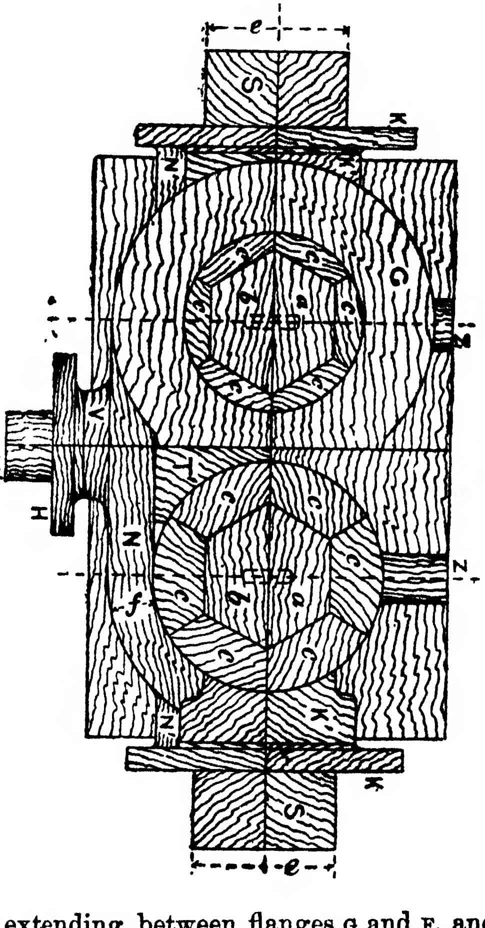


Fig. 191.

cylinders, extending between flanges G and F, and meets the bottom of the passage block N. This leaves a thickness of metal, *g* in Fig. 188, which must be put in the core-box, as will be shown presently. On the passage block N the bosses U V, for steam and exhaust respectively, are screwed, and the flanges H J dowelled on in one piece. Prints L′ M′ are fastened

upon the flange for the steam and exhaust openings respectively. It will be noted that L is a square print, although the hole is round. This was done to keep the core from becoming shifted round slightly in the mould, as it does not fit into any prints at the steam-chest end, whereas the exhaust cores that fit into print M′ also fit into prints at the opposite

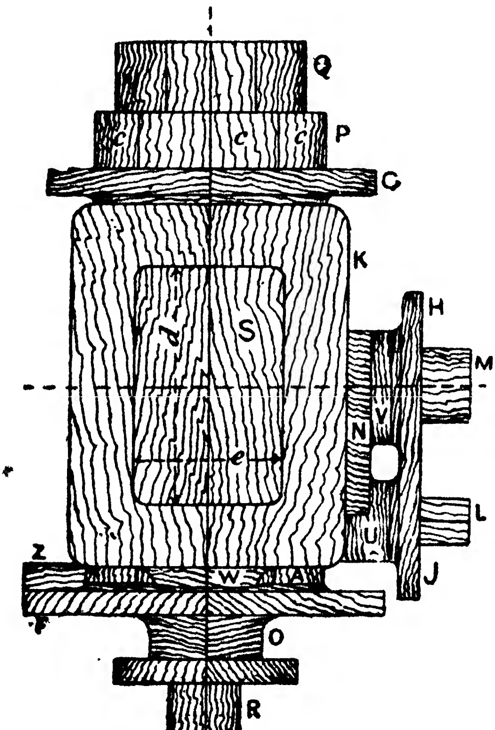


Fig. 192.

end in the steam-chest cores. Pieces fitted at W for the steam-chest stuffing-box, and at Z for the pet-cock bosses, complete the pattern.

The timber shading illustrates the best disposition of the grain throughout. The hollows or fillets are also shown. allowances are made in the cylinders and stuffing-

boxes, and facing on all the flanges and on the port faces, of $\frac{1}{8}$-inch in amount.

The provisions for making the cores are shown in Figs. 194 to 199. Fig. 194 is the board used for striking the central core. The portions *h*, *j*, *k* strike the bore, the neck, and the

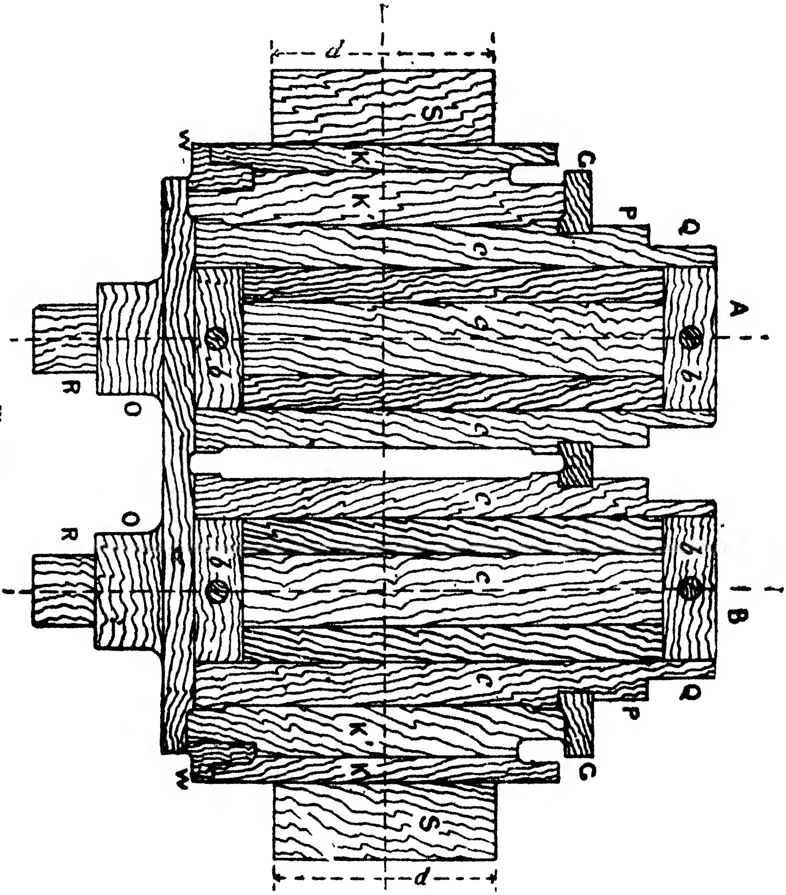


Fig. 193.

stuffing-box respectively, similarly lettered in Fig. 187. The recess *l* is for the arboring *l* in Fig. 187. The portions corresponding with prints Q, R, and head P in Figs. 190 and 192 are also similarly lettered in Fig. 194.

Fig. 195 is the steam-chest core-box, fitting the print S in

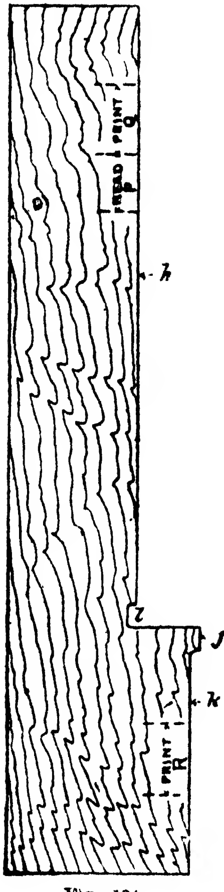


Fig. 194.

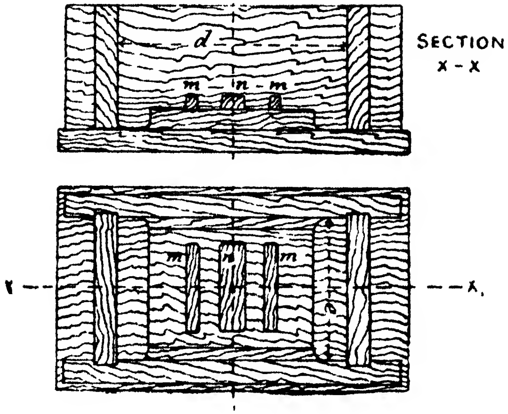


Fig. 195.

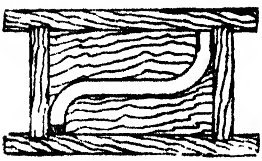


Fig. 196.

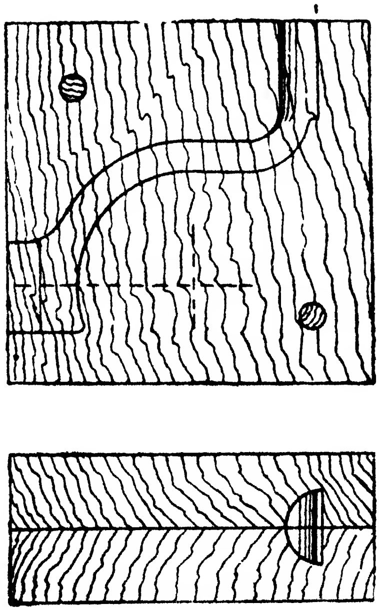


Fig. 197.

Figs. 190—192, the length *d* and width *e* corresponding in each case. A comparison of the two views of the box with the section of the steam-chest recess in the right hand of Fig. 187, and its face view in Fig. 189, will render the relationship of the parts of the box thereto apparent. The steam-ports *m m*, and the exhaust port *n*, in Figs. 187 and 189, are represented by the prints similarly lettered in Fig. 195. The box is framed together with grooved sides and ends, and a bottom board is dowelled on to carry the port facing and prints.

Fig. 196 is the steam-passage box. Its coincidence with

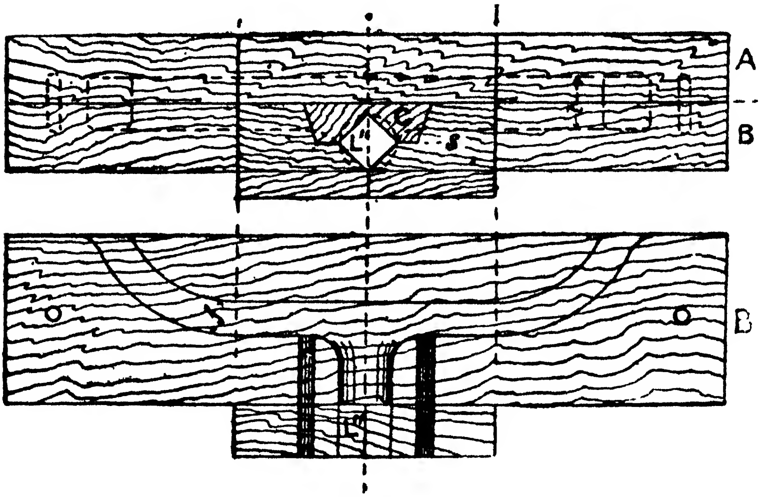


Fig. 198.

the passages *p* in Fig. 187 is apparent at once. Its width is the same as *p*′ in Figs. 188 and 189.

Fig. 197 shows an edge view, and also one-half the exhaust core-box in plan. Its outline is seen at the right of Fig. 188, and the width of the core is seen in plan at *q* in Fig. 187, left hand. The end M″ fits into the impression of the print M′ in Figs. 190—192, and the end *n*′ into the impression of the print *n* in Fig. 195. There are two cores jointed at *o*, the centre of the print. The two passages could, however, be made in one core just as is done alternatively in the next box, Fig. 198, for the steam inlet to the steam-chests. The two halves of this box A B are shown dowelled above in plan; the half B is shown below open in the joint-face. Comparing the box with

Fig. 187, L″ is the square opening, corresponding with the print L′ in Fig. 190, and the reason why this opening is not in the same plane with the passage itself is clear on a comparison with the left hand of Fig. 187. This necessitates a jointing along the plane *r*, and along the plane *s* in the core-box. The half B is shown open on both planes, the half C that

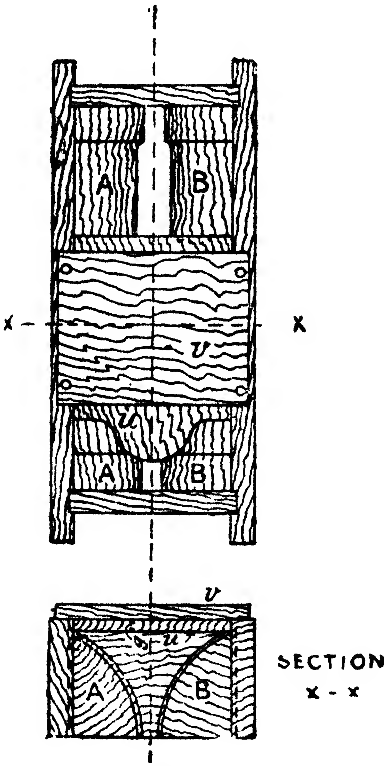


Fig. 199.

fits on the plane *s* being removed. The curvature and width of the passages coincide with the curvature and width of the exhaust passage L in the right hand of Fig. 188, and the width of the passage in the other direction is *t* on the right hand of Fig. 187. The timber shading explains the arrangement of grain.

Fig. 199 is the box for taking out the space T in Fig. 188,

with the print T in Figs. 190 and 191. A framed outer box is made of the same length as the pattern between flanges F and G, and of the width of the print T′; and blocks A B are put in corresponding in section with the cylinder bodies A and B in Fig. 187. A piece, *u*, is fitted within, corresponding in area and in position with the portion of the passage block N in Fig. 187 that covers the space T, and this is held in correct position with a batten V screwed or dowelled upon the box-edges. The thickness, *g*, of the piece *u* is equal to *g* in Fig. 188, and forms the metal below the passages.

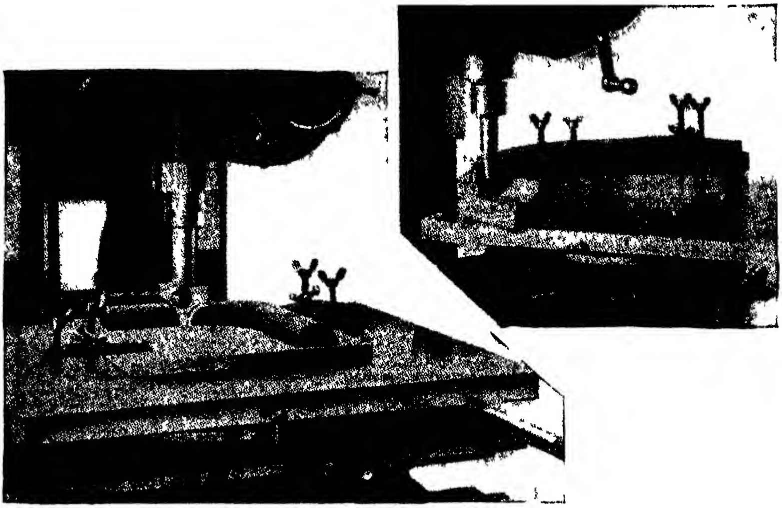


Fig. 199A.

Two 'Set Ups" on the "Wadkin" Pattern Miller.

CHAPTER X.

ENGINE CYLINDERS STRUCK IN LOAM.

The use of Loam.—Foundation-plate for striking on.—Bottom-board.—Body-board.—Attachments of Cylinder.—Loam Bricks.—Top-board.—Head.—Central Core.—Closing the Mould.—Variety of Design in Cylinders.

A MOULD taken from a wooden pattern is the most convenient and economical method of making a small cylinder, but it would obviously be too expensive in one of large diameter, say, ranging from 3 feet to 8 or 9 feet. If, then, we had to make a cylinder so large in diameter, and perhaps 6 feet, 8 feet, or 9 feet long, we should "strike it up" in a loam mould Foundry loam is a mixture of various sands and horsedung, which mixture, unlike the common sand, has the property of hardening when dried. Being plastic when in the wet state, it can be "struck up," or made to assume any shape that may be required. The necessary outline is imparted to the mould by a board having a "chamfered" edge, which board swivels on a bar set upright, and working in a step. Portions of work, not circular, as valve faces, feet, passage blocks, &c., must have their corresponding patterns made separately, just as in the case of an entire wood pattern, and embedded in the loam, there to remain until it is dry, when they are drawn out as from ordinary sand.

In our large cylinders we begin with the bottom flange. Make a rough cast-iron plate, 5 inches or 6 inches larger than the diameter of the flange, and about 3 inches thick; cast four projecting lugs on its circumference, and let its upper surface (Fig. 200, A) be studded over with points or "jaggers" to hold the loam. A hole in the centre is necessary, to allow the central striking bar to pass down to its socketed footstep. This plate will be placed on any convenient support, usually wooden blocking B, B, and daubed over with thick loam. The first

striking board, C, notched to correspond to the semidiameter of the flange, minus half the diameter of the striking bar, D, also shouldered back to the thickness of the flange, and carried out parallel a few inches beyond its edge, will be swept over this surfaco. By repeated strikings, and the final application of thinner loam, the shape of the edge and face of the bottom flange, together with a joint surface, will be obtained. This will then be lifted by the projecting lugs which are cast on the foundation-plate, taken to the stove, and dried. When dry, it will be sufficiently hard and firm to sustain the body of the cylinder which will be built upon it (the latter might, however, be built on a separate plate, and then transferred). The outer board for striking the body, framed together with half-lap

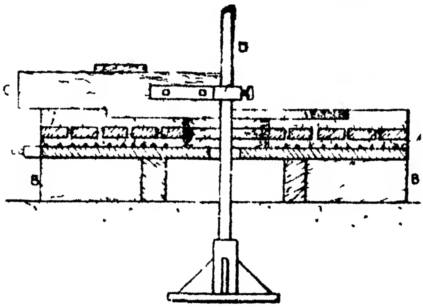


Fig. 200.

joints, cut at the top to form the flange and the upper joint, and chamfered, will be screwed to the bar, with its bottom end level with the face of the flange (Fig. 201). The flange itself will be temporarily filled with sand. On the flange joint already made the moulder will build up the body of the cylinder. Outside, and about an inch away from the edge of the board, he will build courses of bricks, bedding each successive course on a thin layer of loam, until the proper height is attained. Within this wall of bricks loam will be laid, and struck truly circular by means of the board. The upper portion of the board will strike the top joint, coinciding with the face of the top flange, and that joint will have a "check" about 1½ inch deep, and standing about 4 inches away from the edge of the flange, which check becomes a guide for the concentric setting of the top mould. Passages, valve faces, and flanges, of one type or another, will be required. These, as we said before, will be made as patterns, and embedded in the loam, and, of course, where they come the

bricks must be left out. Portions of these may require to be loose for convenience of drawing in, and while some pieces will be drawn *into* the mould, others perhaps, as steam-chest

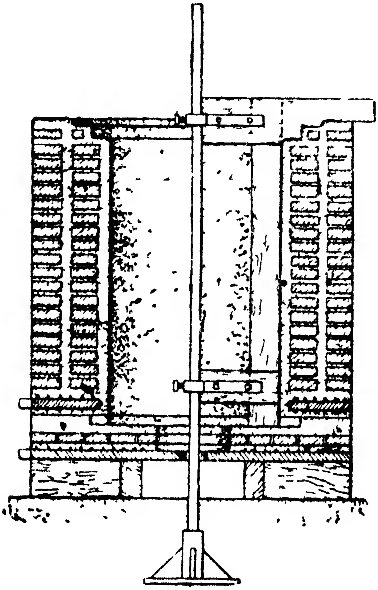


Fig. 201

flanges, will have to be drawn from the *outside*. Where a flange is drawn from the outside, its face will be made by a

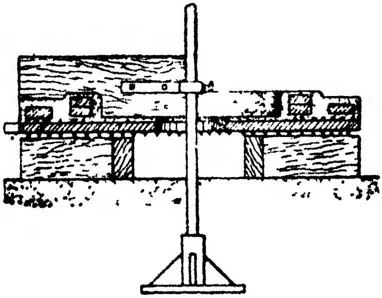


Fig. 202.

flat cake of loam laid against the outside after the mould is finished. Where there are wide flanges or brackets in close proximity to the body of the cylinder, there is a

danger of their breaking off during the contraction of the metal, owing to the unyielding nature of the bricks. In such cases "loam bricks" are used, *i.e.* bricks made of loam and dried. These will crush and give more readily to the shrinking of the metal.

The face of the top flange will be made by a board showing a joint exactly the counterpart of that on the body-board, having its "check" cut the reverse way to that shown in Fig. 201. A tongue must be screwed upon it to give the proper head metal, say six or eight inches (Fig. 202). The flange face will be struck on an iron plate similar to that which was used for the bottom.

Meanwhile the outside of the cylinder will have become sufficiently set for removal to the stove. It will be detached from the bottom plate for this purpose, and while it is drying the centre core, representing the bore of the cylinder, will be struck up. Here also a board in a vertical position will be used, striking a coating of loam on a body of bricks (Fig. 203). This, too, will be dried and removed.

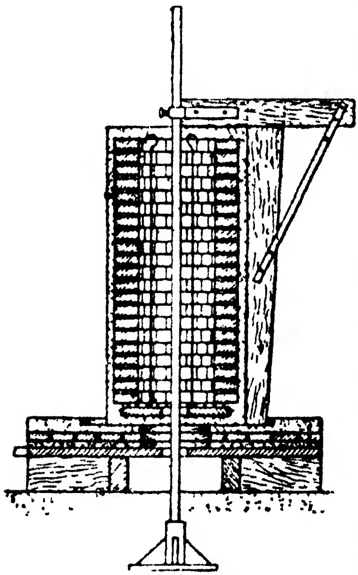


Fig. 203.

All the parts having been struck and dried, the moulder then blacks their surfaces and puts them together. Fig. 204 shows the mould in section. The passage cores, not shown, for which core-boxes must be made in the usual way, as described in the last chapter, will be fixed, and the top and bottom parts of the mould will be secured by bolts, embracing the lugs on the top and bottom plates. The whole will then be placed in the foundry pit, due provision having been made for the bringing off the gas from the mould, and the entire affair is rammed round with sand previous to casting.

Cylinders vary very widely in general design; consequently a detailed description of one pattern will not apply to another. In this, as in many other classes of work, a pattern-maker will seldom get two jobs exactly alike. He must, therefore, find

safe and sufficient guide in the general principles of his trade, assisted by the teachings and warnings of experience. Thus he must not only foresee whether or no his pattern, when constructed, will deliver from the sand, but whether the cores, as well as the mould, can be put together in detail, and so securely that nothing shall be washed out of place by the rush of metal. He will also consider where core prints can be used with best advantage, since sometimes prints will be dispensed with and "chaplets" used instead; frequently also prints in cores will form the supports for other cores.

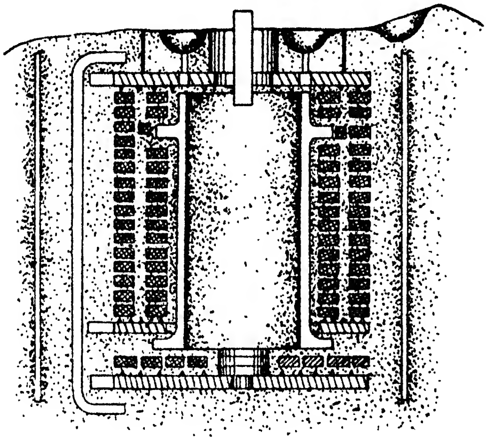


Fig. 204.

Cylinders are sometimes cast double; frequently they are jacketed; often the steam-chest forms a part of the cylinder casting. The feet are sometimes in awkward positions and of queer shapes. Of late years engines have come into common use in which cylinder, bedplate, and guide-bars are cast all in one. In these matters of detail the general principles we have laid down, coupled with the knowledge to be gained by experience, are sufficient guide to the workman who may never have seen a piece of work precisely similar to that which he may at any moment have to take in hand.

CHAPTER XI.

FLYWHEELS.

Pattern Wheels.—Wheels struck up.—Wheels with Cast-iron Arms.—Striking the Core-bed.—Size of Cores.—Form of Core-box.—Laying Cores in position.—Top part of Mould.—Wheels with Wrought-iron Arms.—Sweeping up the Ring.—Core-box for the Arm Bosses.—Casting of Central Boss.

FLYWHEELS permit of very little variation in design. We may divide them into two classes—those with cast and those with wrought-iron arms. The former are the more rigid, the latter are the safer.

Except in the case of standard wheels made for engines which are a speciality, and which, therefore, require a repetition of castings all exactly alike, very few flywheels are made from patterns, but are struck up. If, however, we had to make a pattern for one of these standard wheels, or one for a small engine, we should proceed as follows:—

Build up the rim in courses of segments, as in the case of a toothed wheel, and lock the arms together, according to directions also given for that work. When the rim is built up to half its full thickness *plus* half the thickness of an arm, turn its inner portion to the correct diameter, and notch out reeesses to receive the ends of the arms. Glue these in, and above them glue on the remaining courses of segments. Then complete the turning of the rim, and work the arms to shape (Fig. 205). If the wheel were large it would be more convenient to work the arms before glueing them in place, leaving only the radii which merge into the rim to be finished in position. Suitable bosses will then be turned and screwed on the

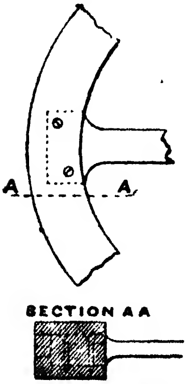


Fig. 205.

centre of the wheel, and the core print put on the centre of the boss which is in the down side of the mould.

But suppose we have to make a large wheel, ranging anywhere between 4 feet and 12 feet in diameter, without a pattern. We should proceed in this way. We should make a board chamfered like a loam board, and, like it, fastened to a centre bar (Fig. 206), to strike a ring of sand of the same diameter as the periphery of the wheel, the top edge of which ring would be struck off level by the board to form the joint for the top of the mould. The disc inclosed by this ring would be struck to a true plane of sand at a depth below the joint equal to the thickness of the wheel rim. During the process of striking, the sand forming the outside of the rim will break away and fall down to a certain extent. A sweeped piece, worked to the proper radius and depth, will therefore be necessary to mend this up smooth and sharp (Fig. 207).

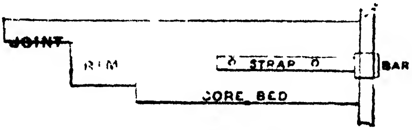


Fig. 206.

Fig. 207.

Further, if the flywheel be shallow, the striking board must be modified a little. From the inner diameter of the ring right away to the centre it must be cut deeper by 2 inches or 3 inches, thus recessing the bed below the edge of the rim by that amount (Fig. 206), where the core-bed is seen to be below the face of the rim. The object of this is to get sufficient depth of sand and grid room in the cores which are to form the arms. There should not be less than 1½ inch or 2 inches for sand, and 1 inch for grid allowed over the thickest part of the arm.

Two cores, placed face to face, make up an arm. They are jointed in the circular plane of the wheel, and extend from the inner diameter of the rim to the central boss. If, then, our bed were level with the edge of the rim, our core-box would be just half the depth of the rim. If the core-bed were sunk lower than that edge, the core-box would be thicker than half the depth of the rim by that amount.

The box must be sufficiently wide to give 3 inches or 4 inches in breadth of sand for radial jointing where the cores abut against each other around the boss. There should also be enough sand to include the radii or hollows where the arms

sweep into the rim. It will be framed together in the usual fashion of rectangular core-boxes, with two sides (Fig. 208), having their two ends kept in position by shallow grooves. The end which represents the inner diameter of the wheel will be hollowed to the same sweep as that diameter. At the opposite or boss end, two symmetrically shaped joint blocks, *a, a,* will be fitted, including between them an angle of 60°, that being the angle which the cores will occupy in relation to

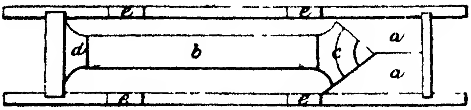


Fig 208.

each other in the mould for a six-armed wheel. On one edge of the box so made a bottom board will be dowelled.

We have now our box in outline, requiring the arm to complete it. As the cores are to be jointed in the centre, both top and bottom cores must evidently be alike, and our arm will represent only a *half* section.

Prepare, therefore, three pieces of wood, representing respectively the straight portion of the arm, *b*, the sixth part of the boss, including the hollow by which it sweeps into the straight arm, *c*, and the sweep curving into the rim, *d*, each in half section. Dowel or screw these in the centre of the core-box and upon its bottom board. A sixth part also of the central core print may be put on the boss segment, if the box is deep enough to allow of this, or the core may be centred in the

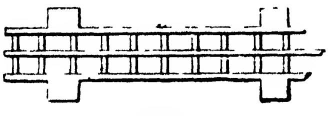


Fig 209.

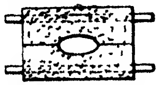


Fig. 210.

mould after the arm cores are laid in place. Notches, *e, e,* will be cut out on the top edges of the core-box to take the grids (Fig. 209). A grid is a cast-iron frame of latticework, which the moulder uses for the same purpose as the bricks and plates in a loam mould, viz. to give rigidity to the core. Those portions of the grid which project beyond the core are in this case also used for the purpose of screwing the top and bottom cores together before casting.

The cores, when made, are dried, blacked, jointed (Fig. 210).

and laid in the mould, as indicated by the dotted lines in Figs. 211, 212. There will then be open spaces, *a*, between each double core, which must be filled up to form that portion of the rim not already formed by the sweeped ends of the arm cores. These intervals may be filled up either by distinct cores, involving a box, or by a sweep, against which the moulder will ram green sand, similar to the one used for mending up the outer sand, but cut in the opposite way, viz. hollow, and of the same radius as that of the inner part of the rim.

Then there remains the top of the mould. This is struck by a board, and generally in loam—sometimes, however, in green

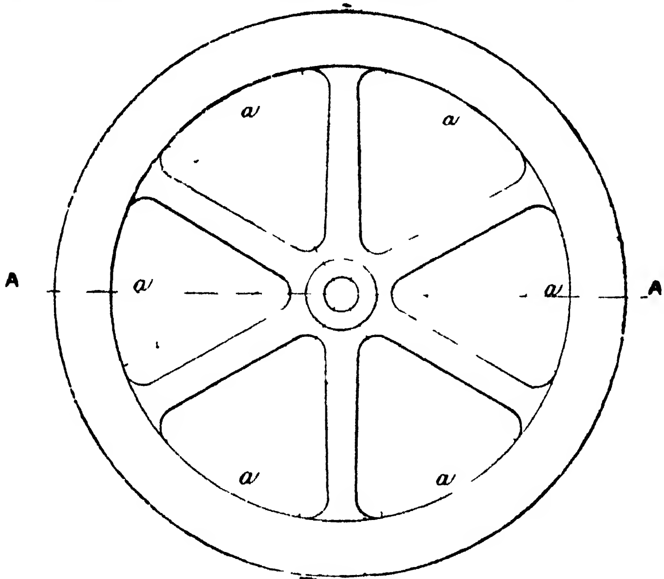


Fig. 211

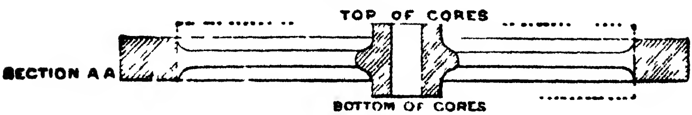


Fig. 212

sand, viz. ordinary moulding sand. If in loam, it is struck on a circular cast-iron plate, roughened over as usual to hold the loam; if in green sand, a top-part box will be used. If the cores are deeper than the rim, as in Figs. 206, 212, the board will be shouldered as in the bottom. This completes the wheel as far as the pattern-maker's work is concerned.

But in wheels running at high speeds, and especially in wheels badly proportioned, people have learned to distrust cast-iron, and though the massive rim is retained, it is in many cases considered preferable to make the arms of wrought-iron. In wheels made entirely of cast-iron the disproportion often existing between the heavy rim and the comparatively slight arms sets up initial strains within the casting at the time of cooling, which become a perpetual source of insecurity. Hence reason and experience have decided against the use of such wheels for quick-running and heavy machinery, and in favour of those with wrought-iron arms. The strength of these wrought-iron arms also must bear a proper relation to the momentum of the wheel, else they will twist off close to the boss, as I have seen in more than one instance.

To make such a wheel, quite a different mode of procedure must be adopted from that just described. In the first place

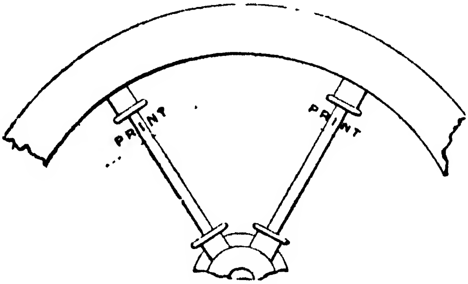


Fig. 213.

we shall make the rim in another way, though still without a complete pattern. We shall have no board, but a sweep of exactly the same section as the wheel rim, and a foot or two longer (according to the size of the wheel) than the sixth part of its circumference (Fig. 213). Exactly one-sixth part of the inner circumference of the wheel (=its radius) will be marked on the inner edge of the sweep, and on the centres so marked prints and half bosses for the reception of the arms will be fastened (Figs. 213, 214).

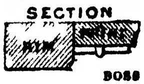


Fig. 214.

Then the sweep, with its bosses and prints, is rammed up in sand level with its top face, and withdrawn. It is then carried round exactly one-sixth of its circumference, and its right-hand print and boss is dropped into the impression just made by its left-hand print and boss. There the

sweep is again rammed up, to be again withdrawn and removed, until the ring, with its six bosses and six prints, is completed. The reason why prints are used is obvious on a moment's consideration. The wheel being moulded in segments renders it impossible to ram up a top part in place, as in the case of a pattern, and, as a consequence, the only possible way of making the top half of the boss is by a core.

This core-box will consist of a rectangular frame, having one side sweeped to the inner curve of the rim, and a bottom board, on which will be fastened the half boss and print (Fig. 215, enlarged for distinctness). These must be exactly in the centre of the box, and of exactly the same shape and size as those which are fastened on the rectangular print; otherwise there will be overlapping of joints in the casting. In fact, it is usual to joint the two boss halves and turn them together; then, taking them apart, use one for the core-box, the other for the pattern. The print in the boss is of the same diameter as the wrought-iron arms, and that part of the arm which enters the boss is jagged or notched, in order that the cast-iron may embrace it the more securely.

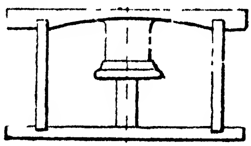


Fig. 215.

The mould for the rim having been completed, the arms are laid in the prints ready for their reception, the rectangular cores are laid over their ends (each in its print), and the entire ring is covered with a flat surface of loam or green sand. The rim is then cast and allowed to cool. When cool, but *not quite cold*, the boss will be cast on the opposite or central ends of the arms, which also will be jagged to prevent possible loosening.

The reason why the boss is cast on after the ring has cooled is that the contraction of the ring in cooling is so largely in excess of that of the boss, that the rigidity of the latter, supposing it were cast at the same time with the ring, by preventing the arms from coming inwards, would infallibly either bend the arms or fracture the rim. Hence the boss is always cast when the rim has nearly, but not quite, done contracting, there being, of course, a slight amount of shrinkage on the boss.

A complete pattern boss is wanted, jointed in the centre of the arm bosses in a direction parallel with the plane of the wheel. The boss mould also is made in halves, and usually dried.

CHAPTER XII.

MISCELLANEOUS ENGINE WORK.

Eccentric Sheaves.—Straps.—Slide-valves.—Guides.—Cross-heads.—Lever Bracket.

As the principles involved in pattern-making are the same whatever be the ultimate use of the article to be produced, the writer feels justified in adding the following items of engine work to the preceding heavier examples which were purposely included, offering as they do good examples of the pattern-maker's craft.

Double eccentric sheaves, forward and backward, are cast together. The pattern itself consists simply of two plain discs dowelled together, the grooves being turned out in the casting. But the dowelling together of the discs requires care. Proceed thus:—Say we have an engine with $\frac{3}{8}$-inch lap, $\frac{1}{16}$-lead, and $2\frac{1}{4}$-inches throw of sheave. Strike a circle $2\frac{1}{4}$ inches diameter on the centre of the crank shaft, and draw a line through its centre (Fig. 216). At a distance away from this

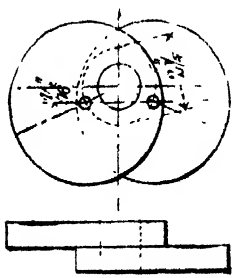


Fig. 216.

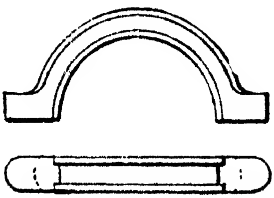


Fig. 217.

line $= \frac{7}{16} =$ lap and lead, and parallel with it draw another line. The two points where this second line cuts the $2\frac{1}{4}$-inch circle will be the centres of the two sheaves, forward and back-

ward respectively. Strike the circles representing their diameters; lay one disc upon the drawing on its proper circle, and dowel the other upon it perpendicularly over its circle, adjusting it with set square. Put the print for the shaft-hole on the pattern for one pair of sheaves first, say the right hand. Cast one off, then remove the print to the other centre for the left-hand pair.

As small eccentric straps (Fig. 217) are usually made in gunmetal, the grooves in many instances are cut out in the pattern. The neatest way to get out the inside of the strap with its grooves is to turn it; but as an allowance for facing is given in the joint, which makes the pattern $\frac{1}{16}$ inch more than a half circle, the straps are turned a half at a time, a false block being screwed on the face plate to complete the circle—its face standing $\frac{1}{16}$ inch back from the centre line—while the two half straps are being turned in succession. The outside portion, with its lugs for bolting together, is worked by hand, away from the lathe. The lug or facing for eccentric-rod, and the oil-cup boss (not shown) are put on separately. Straps are moulded at pleasure either on their sides or edges, the latter giving, as a rule, the cleanest metal.

Slide-valves of the D-shaped type are those most commonly used. Ordinary valves are too simple to cause any trouble to the pattern-maker, accuracy being the important condition.

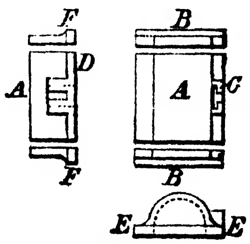


Fig. 218.

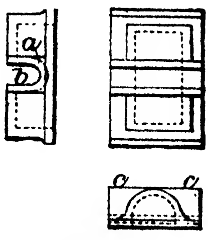


Fig. 219.

The usual D-shaped valve, as the type of the class, is the only one therefore that calls for special notice. A glance at the sketch (Fig. 218) will indicate the way in which it is made. The block (Fig. 218, A) forming the inner portion of the valve is planed to width, and marked out and worked through with gouge and chisel. The sides, B, B, are also worked to shape and then fastened to the block. The piece, C, for the reception of the valve-rod head is fastened in place, and a print for the

nut core bradded on. An allowance of $\frac{1}{8}$ inch is made on the face D for planing, and the same at ends, E, E, for accurate cut-off: a similar allowance also at sides, F, F, for close fitting into the steam-chest.

A D-valve, like Fig. 219, is made in a similar way, except that, after the D shape is worked, a half-round piece, *a*, is glued within, and when dry the recess, *b*, for the valve-rod is worked on the outside, the pieces, *c*, *c*, being fitted and glued round the curve to form the flat edges and ends of the groove.

A valve, like Fig. 220, is made in three pieces, as in the first instance, or cut out of a solid piece of stuff; but the outside, instead of being worked half-round, is partly turned and partly dressed off by hand. Allowance for turning is made also where the eye of the valve-rod slips over.

Transverse Section.

End View.

Longitudinal Section.

Fig. 220.

Figs. 221—225 illustrate the casting of a double-ported slide valve. Here J J are the outer steam ports, communicating with the exhaust arch K; L L are the inner steam ports, opening on the sides of the valve. In Figs. 223—225, M is the hole for the valve rod, made of elliptic form, to allow of free fitting as the valve face wears down; N N are the guide blocks, which slide against the steam-chest covers. The design and construction of this type of valve is so well known and so clear from the figures, that we may at once proceed to the description of the pattern work.

The pattern itself is shown in Fig. 226. Here A is the body, B the flange, C the prints for the inner and outer steam ports, D the print for the exhaust arch, and E the prints for the oval hole for the valve-rod. The pattern moulds with face B downwards to ensure sound metal there, and the prints E, are skewered loosely on. The skewering on of these requires that a joint be made in the mould along the line F F; but there is an advantage as regards the placing the cores in the mould in this method, otherwise the prints E would have been of the pocket form.

There are three core-boxes wanted for this valve, one (Fig. 227) for the outer steam ports J, and the exhaust arch K, in Figs. 221—224; another box (Fig. 228) for the inner steam ports L, in Figs. 221—225; and the third (Fig. 229) for coring out the hole M for the valve-rod, in Figs. 221—225.

Half Plan (Back).

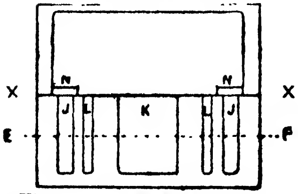


Fig. 221. Half Plan (Face).

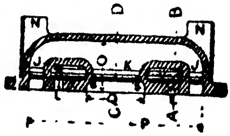


Fig. 222. Section E E.

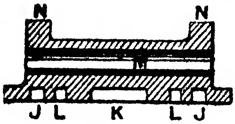


Fig. 223. Section X X.

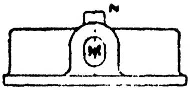


Fig. 224. End View.

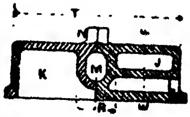


Fig. 225. Half Sec. CD.
Half Sec. A B.

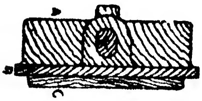


Fig. 226. End View.

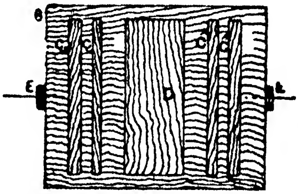


Fig. 226. Plan of Face.

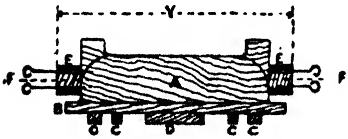


Fig. 226. Side View.

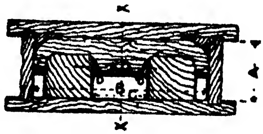


Fig. 227. End View.

Fig. 228. Sec. X X.

Fig. 229.

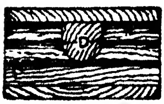


Fig. 227. Sec. X X.

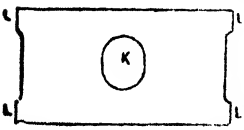


Fig. 231. End View.

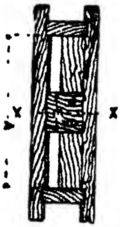


Fig. 228.
Plan.

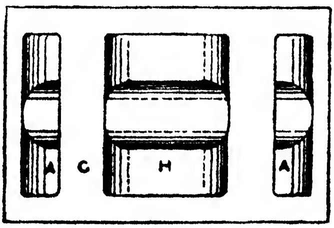


Fig. 230. Plan of Face.

In Fig. 227, the distance A corresponds with the distance O in Fig. 222, plus the print thickness C in Fig. 226; and the length B in Fig. 227 corresponds with the length P in Fig. 222; and the distance C in Fig. 227, with the distance Q in Fig. 222. The width of the piece D in Fig. 222 is equal to the width R in Fig. 225, and, of course, forms the metal around the cored hole M for the valve-rod. In this box everything delivers except the pieces D, which form the extensions at S, in Fig. 222, and these are therefore skewered on. The other portions are fastened to the outsides, and draw directly with them.

The box (Fig. 228) which forms the inner ports L (Figs. 221—225) extends in its length A to the width T in Fig. 225, cutting through the valve sides to give inlet to the steam from the steam chest. The depth B of this box extends to the depth U in Fig. 222, plus the print thickness C in Fig. 226; and the width of the portion C in the box is equal to the width V in Fig. 222. The edge D of the bridge piece E in Fig. 228 corresponds with the edge W in Fig. 222, and its width E with the width R in Fig. 225. It will be observed that there is no provision in this box for the formation of the curves seen in Fig. 222. As is often the case, these are left to be rubbed off the core after it is dried.

The section of the box (Fig. 229) for the formation of the valve-rod hole M is a plain ellipse, and its length is equal to the length Y in Fig. 226, and it is jointed and dowelled longitudinally.

An example of a main-slide valve—that is, one in which expansive working is provided for by means of a cut-off valve sliding on its back face—is shown in Figs. 230—234, and the pattern work in the figures following.

In Figs. 230—233, A A are the steam passages passing through the valve from the back B to the face G; H is the exhaust arch, J the lightening recess, K the hole for the valve-rod, L facing guide strips, sliding against similar strips within the steam chest.

The pattern, Fig. 235, is a plain rectangular block, with facing strips A B, upon the sides, the lower ones B, being skewered on. There are prints B B in this case, of the pocket form for the valve-rod hole; and also prints C D both at top and bottom, for the steam-passage cores. Prints are put upon the top, as well as upon the bottom, because the exact position of the ports is of great importance; and in the absence of the top prints the cores would be liable to tip out

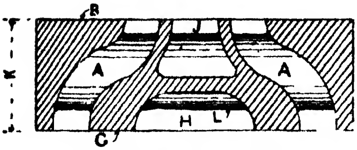


Fig. 232. Section E E.

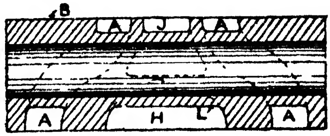


Fig. 233. Section C D.

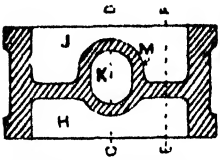


Fig. 234. Section A B.

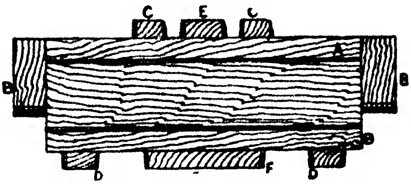


Fig. 235. Side View.

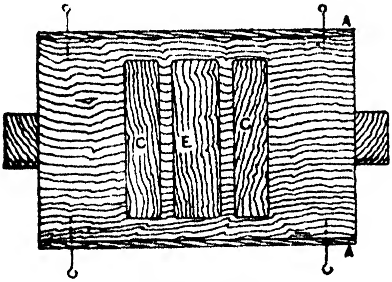


Fig. 235. Plan.

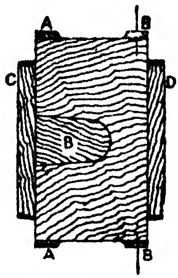


Fig. 235. End View

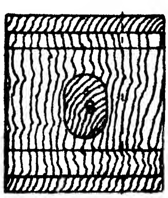


Fig. 236. End View.

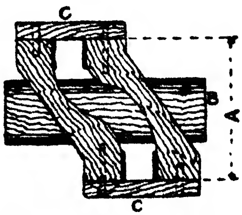


Fig. 236. Section X X.

of truth, one way or the other. Prints are not as a rule used in the top of a mould if they can be avoided, because there is always a risk of the sand in the top becoming more or less crushed thereby. There are prints E for the lightening recess, and F for the exhaust arch.

Fig. 236 is the steam-passage core-box. Its width A equals the width K in Fig. 232, plus the thickness of the prints C D in Fig. 235. The block B, which is slid through holes cut in the sides of the box, forms the metal around the hole for the valve-rod, and corresponds in size and section with the portion marked M in Fig. 234. When the core is

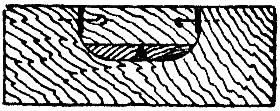


Fig. 237. Section X X.

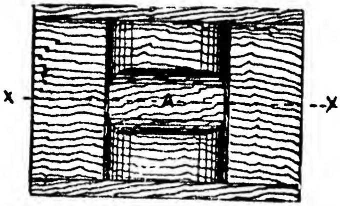


Fig. 237. Plan.

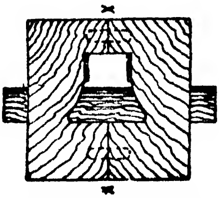


Fig. 238. End View.

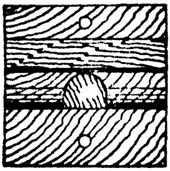


Fig. 238. Joint Face X X.

made the block is drawn out endways, the sides C C unscrewed, and taken away from the core.

The box (Fig. 237) forms the arch of the valve, and the block A forms that portion of the metal seen at L in Figs. 232 and 233. The chipping strips for the cut-off edges are necessarily skewered on.

The box (Fig. 238) cores out the recess J in the back of the valve (Figs. 232, 233), and has its block also, to form the necessary metal around the valve-rod hole.

The box for the valve-rod hole, of elliptic form, is similar to that shown in Fig. 229.

An ordinary steam-chest calls for no special remark, and of a double-flanged one it is sufficient to note that the bottom flange must be left loose from the body. Patterns also for

plain, flat guide-bars are made just like their castings, so we say nothing about them. Instead, however, of the old guide-

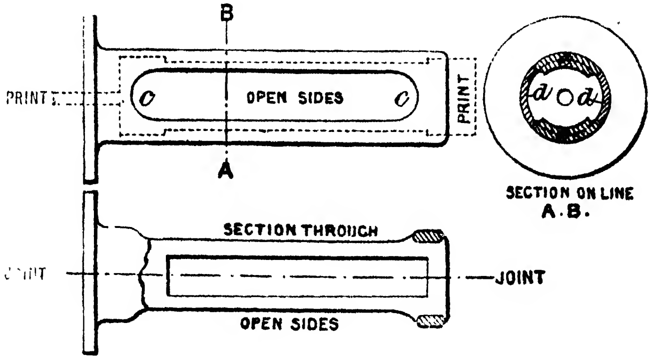


Fig. 239.

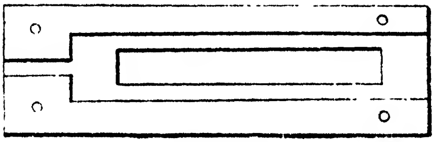


Fig. 240.

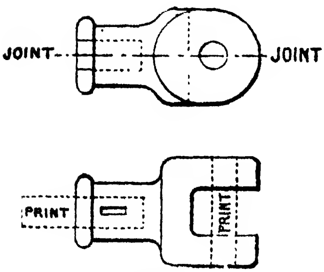


Fig. 241.

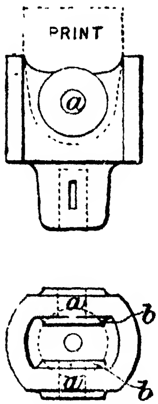


Fig 242.

bars, circular guides, bored to receive a circular cross-head, are now in common use. They are cast in a piece with the cylinder cover, have a massive appearance, require little

fitting, and owing to the large extent of surface over which the friction of the cross-head is distributed, wear for a very long time.

The pattern is made in halves, jointed longitudinally (Fig. 239), and has a print at each end. The open parts of the guide (Fig. 239, c c) are cut on the pattern as far inward as the diameter which corresponds with the body core of the guide (Fig. 239), section, *d*, *d*.

For the core, a box is necessary, owing to the existence of the facings, *e*, *e*, for the cross-head, which will not allow of its being struck up. The box is dowelled in halves, and worked with templets. Fig. 240 shows one half, looking into it from the joint.

The cross-head, or head of the piston-rod, is of the shape indicated in Fig. 241, when flat guides are used, and like Fig. 242 when it works in a circular guide. In the former case the pattern would be jointed and cut out to the shape of the casting, the holes, if large, being cored, with a parallel print bridging over between the sides. In the latter form (Fig. 242) the inside is taken out with a core, the pattern moulding either on its side or on its end, and requiring no joint. In either case the core-box will be jointed longitudinally, and the holes, *a*, *a*, will be cut out in top and bottom boards dowelled on the box body, which boards will also carry the top and bottom facing bosses, *b*, *b*.

Cranks, brasses, pistons and their rings, slipper blocks, governor castings, except when there is something special in their construction, are too simple to need description from the pattern-maker's point of view; so with this chapter we close our remarks on engine work and pass to other subjects.

An example of a flimsy pattern which can be made to deliver itself, but must be cored out if its shape is to be retained for standard service, is the lever bracket (Fig. 243), used on a steam crane for driving the engines. And then the pattern might be jointed down the centre through the lever bosses to mould sideways, half in the top and half in the bottom. But a better method is to make it unjointed, with the sand joint between drag and cope to come along the plane x—x, so leaving everything in the bottom except the plate A and its bosses. This may be dowelled loosely to come in the top, but being so thin that precaution is not necessary.

The main print by which the interior is taken out is boxed up (Fig. 244). It affords a firm base for the pattern. It is

extended sufficiently far on each side of the pattern, in the proportion shown, to sustain the core. The pattern parts are

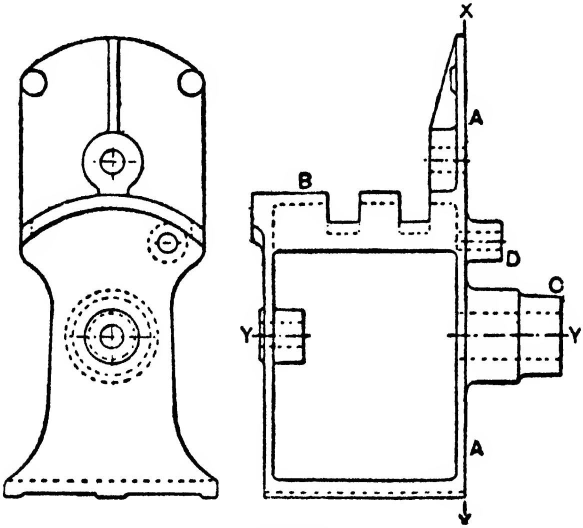


Fig. 243.

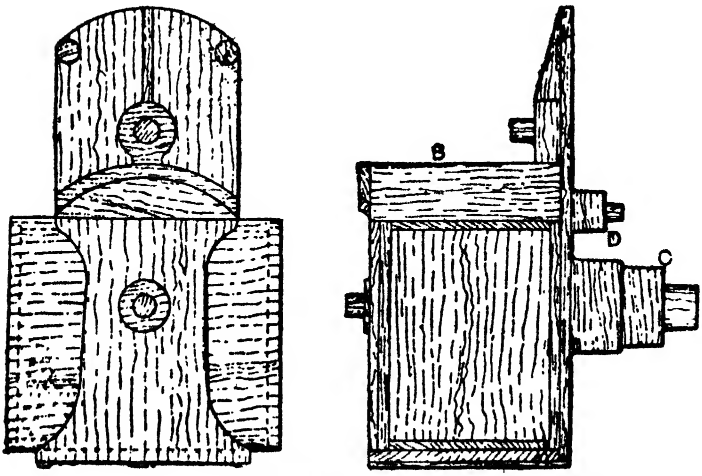


Fig. 244.

prepared and screwed to this in the manner illustrated. The curved portion B in which the lever notches are cast, the

levers pivoting around the axis Y—Y, in Fig. 243, can be worked in a solid block; or when the dimensions are very large it may be blocked up in thinner stuff. The bosses C, D, which come in the top, are dowelled loosely. The details of the pattern work are clearly illustrated.

The main core-box is shown in Fig. 245. The quadrant slots for the levers may be put in this, or they can be made

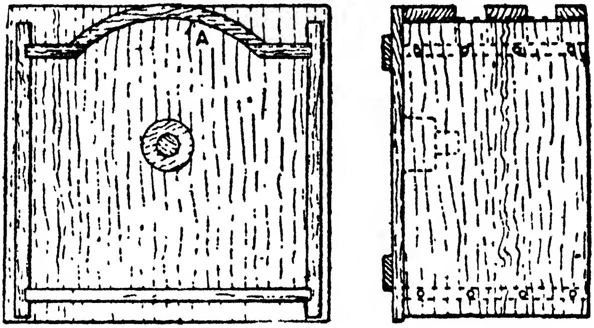


Fig. 245.

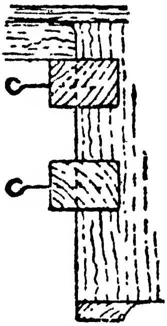


Fig. 246.

Fig. 247.

in separate boxes, both methods being commonly adopted. If they are formed in separate boxes, prints are put on the pattern as shown in the detail at Fig. 246. The cores then, made in a box like Fig. 247, are inserted before the main core is put in, which core abuts exactly against the curved edges of the small cores. If they are included in the main core they have no prints. But the main box is then rather weakened at the curved portion through which the quadrant

slots have to be formed. This is the method shown in Fig. 245. This part A must be of the same thickness as that portion of the casting. Instead of including the inner curve only, it must include the outer curve. Where the slots come, the portions must be left loosely dowelled together, or the core could not be withdrawn from its box. On the whole, therefore, it is better to make separate cores and outside prints. The notches into which the levers are sprung round the top curved edge of A (Fig. 243), for the different cuts-off, are not cored, but are cut by the fitters.

A small round core is carried in the bottom of the mould in the print seen in Fig. 244. It is well to put a top print in the core in the boss (Fig. 245). The round cores in the top are carried in prints on the bosses C and D (Fig. 244). Or they may be put in the main core-box and shallow parts only in the top, to serve to steady the cores, and prevent them from becoming washed out of centre.

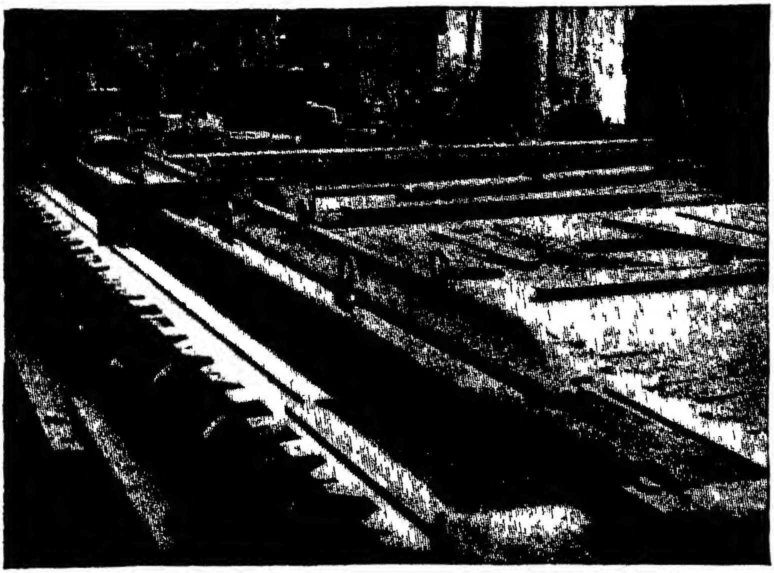


Fig. 247A.

Core being made in the bottom half mould for a "Meehanite" Boring Bar, 56 feet long, and weighing 40½ tons (see p. 367).

Courtesy, International Meehanite Metal Co. Ltd, London.

CHAPTER XIII.

BOILER FITTINGS AND MOUNTINGS.

Dead-plate.—Marking and Fitting.—Fire-bar.—Allowance for Play.—Bearer.—Door Frame.—Building up of the Pattern.—Door.—Valve Seatings.—Safety-valve Shell.—Valves.—Sweeped Fire-bars —Mud-hole Door Frames.—Man-hole Frames.

LANCASHIRE and Cornish boilers are fired internally, the latter being constructed with a single furnace tube, the former with two, and with cross-tubes besides passing through the furnace. The pattern-maker has to prepare dead-plate, fire-bars, furnace front and door, seatings and valves, and other attachments. Some of these have to be fitted to the boiler, and a few general hints relative to these matters may very properly be borne in mind.

The dead-plate (Fig. 248) is that portion of the fire-grate surface lying just within the front end of the boiler, and it ranges from 9 inches to 15 inches or 18 inches in width, according to the capacity of the boiler. It slopes downwards and backwards, and either rests upon angle iron brackets fastened to the sides of the fire-box, or simply against the boiler sides. In order to fit it correctly, the workman marks its position at the boiler front, and also the amount of drop or slope which the fire-bars make where they abut against the bridge (about 1 in 10), and straining a chalk line between these points, strikes the line of slope on each side of the fire-box. To these lines the dead-plate pattern is fitted, and a few chipping strips, *a*, *a*, sufficiently thick to compensate for the contraction which the plate will undergo, and to allow of a little fitting besides, are fastened upon the ends. At its front end the plate either abuts against or rests upon a flange upon

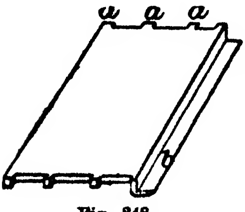


Fig. 248.

the fire-door frame, and at the back it is recessed, *b*, to receive the ends of the fire-bars.

The fire-bar is a simple pattern of the annexed shape, Fig. 249. It is tapered in section to allow the ashes to fall freely downwards, while the upper portion is left parallel to

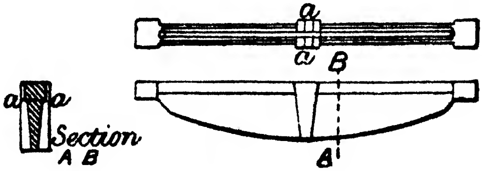


Fig. 249.

keep the air-space parallel and equal during the burning down of the bars. The central thickness pieces, *a*, *a*, are put there to prevent the twisting of the bar sideways. Bars like this, when made in quantity, are usually made from iron patterns, which are moulded by simply bedding in. Fire-bars should never be made a tight fit, as they expand permanently with the heat, but a play of about 1 in 24 should be given at the ends. The cast-iron bearers for the bridge and for the fire-bars are made of an L or T section, and are fitted similarly to the dead-plate, Fig. 250.

A fire-door frame is shown in plan, and in section in Fig. 251. The plate, A, is framed together with segmental pieces and half-lap joints, preferably to cutting it from a single piece

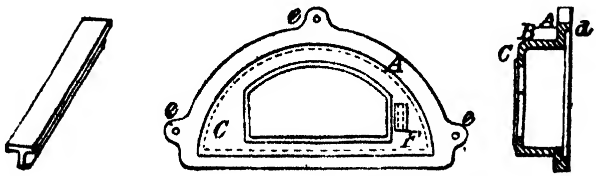


Fig. 250. Fig. 251.

of stuff, since the taking out of the central portion would leave short grain at the sides. The hooded portion, B, is glued up with thin segments, cut through with gouge and chisel and screwed upon the plate. The front, C, is halved together with half-lap joints, and screwed to the face edge of the hood. A narrow chipping strip, *d*, is run round in segments on the face which bolts to the boiler, of sufficient depth to clear the rivet heads, and a thin facing is bradded to that portion upon which the door folds. Lugs, *e*, *e*, *e* for attachment, and, a lug, F, on

which the door hinges, cored out with pocket prints for the hinge pin, completes the pattern.

The pattern of the door (Fig. 252) consists of a thin plate, having a couple of hinge lugs and a thin facing on the front for chipping. Provision will often be made for draught by a revolving ventilator or a sliding grid, the holes for which are cored out. If the fire-hole opening is wide, a double door is used in preference to a single one.

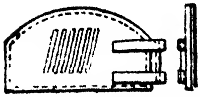


Fig. 252.

Seatings for the valves and cocks are made in cast iron, and riveted to the boiler. Fig. 253 shows the pattern of a seating of this kind. It consists simply of a curved flange, A, and boss, B, having T-headed recesses cast in. The flange may either be fitted to the boiler direct, or a thin templet of wood may be cut to the curve of its diameter, and the pattern worked with a templet cut the reverse of this. The flange itself is made distinct from the boss part, and the two are screwed together afterwards. The stuff for the flange being planed to a parallel thickness, the hollow face should be planed first, and the rounding side gauged and cut with a chisel afterwards, remembering that the rounding of the flange should blend into a hollow around the flat face on which the boss is to be secured. On this boss, plain, square prints will be nailed, and a core-box shaped like Fig. 254, will take out the T-headed recesses.

Fig 253.

Fig. 254.

The shell of a safety-valve consists of a plain, double-flange pipe, with or without a branch for the steam-pipe, depending upon whether the steam is taken from the valve or no. Or, if

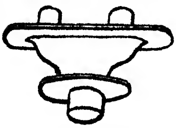


Fig. 255.

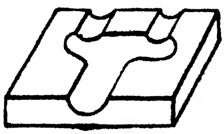


Fig 256.

Fig. 257.

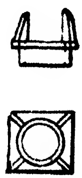


Fig. 258.

there be two valves, as in large boilers, it consists of a double bend pipe (Fig. 255), a core-box (Fig. 256) being necessary with the latter. The valves may be flat discs (Fig. 257), maintained in position with guides attached to the seating

(Fig. 258), or mitre, with three or four wings (Fig. 259), having either a top pin, A, or a recess to produce unstable equilibrium, and prevent the tendency to sticking (Fig. 260). The patterns of these valves are all made like their castings,

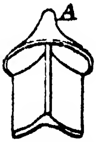


Fig. 259.

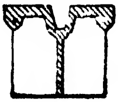


Fig. 260.

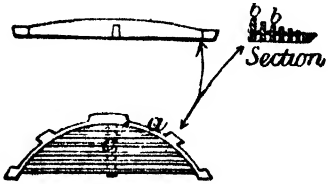


Fig. 261.

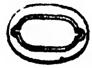


Fig. 262.

the wings being cut separately from the discs and studded on, either fast or loose. Mahogany should be used, and they mould just as they stand when in natural position.

Vertical boilers, for steam cranes and small stationary engines, have fire-bars of a sweeped outline (Fig. 261). These are sometimes cut out of solid mahogany; but the best way is to build up the rim, *a*, in segments, and, having cut that to shape, to fit the bars, *b*, already planed to their thickness, into very shallow grooves, about $\frac{1}{16}$ inch deep, cut in the rim. The connecting strips, *c*, are glued in afterwards. These bars rest upon a ring of wrought iron set in the interior of the fire-box.

Mud-hole doors are fitted opposite to every cross tube and at the bottom of the boiler. These are plain oval castings, held in place with a tightening screw. When the boiler is cleaded, as these vertical boilers often are, the cleading is screwed to a casting made to encircle the hole. These are of the annexed shape (Fig. 262), and being extremely thin, are either made from metal patterns or are cored out. The man-hole in a cleaded boiler has a frame also precisely similar (Fig. 263), but, of course, proportionally larger. For this a wood pattern is built up in segments, and the flat flange which takes the cleading being thin, is curved round and fastened to the built-up portion. But a metal pattern is necessary for durability, and it is cast in iron if for frequent use, or in lead if used for different boilers having different diameters, and therefore requiring some alteration of curvature.

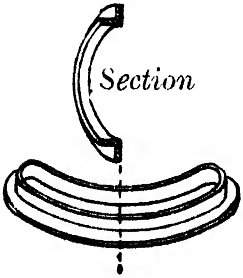


Fig. 263.

CHAPTER XIV.

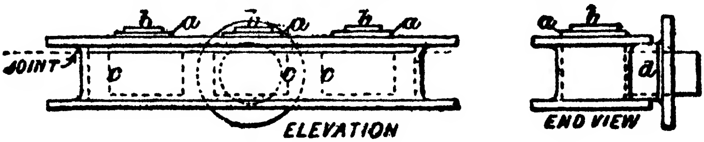
PUMPS, COCKS, AND VALVES.

Three throw Pumps.—Suction-box.—Delivery-box.—Jointing.—Barrel. —Its Core.—Bucket.—Air-vessel.—Strainer-pipes.—Their Cores.— Sluice-cocks.—How Moulded.—Gunmetal Faces Cast and Turned in. —Plug.—Nut.—Force-pumps and Core-boxes.—Small Brass Work. —Globe-valve.—Methods of making Cores.

The varied character of pump work forbids all except a brief description of the commoner forms. The essential parts are barrels, plungers or pistons, suction and delivery boxes, more or less elaborate in detail, and air-vessels. Single-barrel, two-throw, three-throw, hand and steam, single and double-action pumps, vary more in details than in principle or general design, and are not usually very intricate. But almost always the internal portions are cored out, and the core-boxes are generally of the most importance, often involving more work than the patterns themselves, and in certain cases requiring very great care on the part of the pattern-maker.

Let us run through the main patterns for a set of three-throw pumps first of all. The pattern of the suction-box is made as indicated in Fig. 264. One flange at least, sometimes both flanges, are dowelled on to the body, and upon one of these flanges are fastened the facings for the barrels, *a*, *a*, *a*, and the prints, *b*, *b*, *b*, for the holes, that flange moulding downwards, or the reverse to the figure, which shows the box as it stands in natural position. In standard patterns it is customary to work the hollows around the flanges, and then the loose flange will be planed thicker by that amount. Sometimes, instead of a mere suction-box, where the valves rest upon the facings, *a*, *a*, *a*, we have a clack-box—that is, a box which either contains the valves on their diaphragms inclined at an angle towards the front, or else on the top of a suction-box cast separately and bolted up from below. Then there is a door-

way, dotted at *c*, *c*, *c*, cast in front of each valve aperture, so that any temporary defect in either of the clack-valves may be seen and remedied without removing the barrels or taking the structure all to pieces. Where this is the case these holes will not require to have prints upon the pattern. If



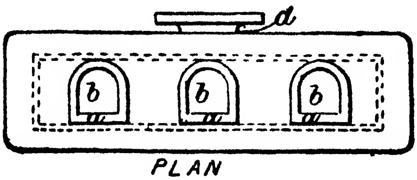


Fig. 264.

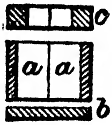


Fig. 265.

there is a branch in the bottom for the suction it will be studded on loosely, and its flange—unjointed—will be slipped loosely over the print. If upon the side, *d*, the branch will be fast, and the flange either slid loosely over, as in the first case, or parted in two, the top half being left loose.

The core-box is usually made in several pieces (Fig. 265). The two blocks, *a*, *a*, dowelled, are cut to form the inside of the shell. If holes are cored for doorways, as supposed above, *c*, *c*, *c*, they are cut in the side of one of the blocks—the thickness of that block being gauged to represent the metal-thickness. A bottom board, *b*, is dowelled on, and a top board also, *c*, the latter in halves, and dowelled, and being equal in thickness to the thickness of the top flange together with its facings and prints. Holes are cut in the latter piece of the same shape and size as the prints.

The delivery-box (Fig. 266) is not very different from the suction. In this, also, one or both flanges will be loose; facings to receive the barrel ends, *a*, *a*, *a*, and prints, *b*, *b*, *b*, for their apertures will be fastened on. There will be a delivery branch somewhere or other, in which the same conditions of moulding will obtain as in the one for the suction-box, and probably a facing, *c*, for the air-vessel. The core-box (Fig. 267) will be constructed similarly, in regard to joints, apertures, and so forth; but the hole for the air-vessel. *a*, will

cut through the top piece. The core for the delivery branch will not be made in the main core-box, but as a separate piece, and it will rest in its print and merely abut against the body core.

Jointing the patterns in the way described means using a three-parted box in the foundry, with its two sand joints. But in most cases there is no objection to jointing through the centres of the prints, as indicated by the dotted line, and

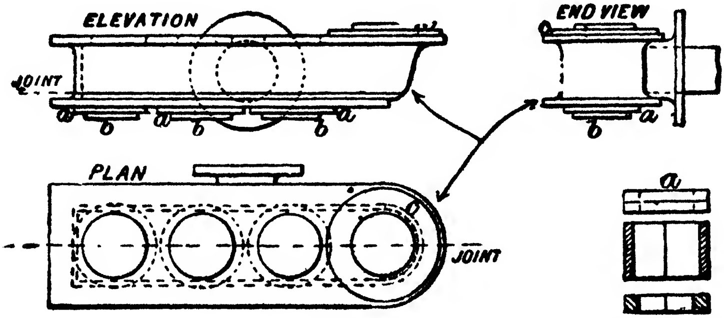


Fig. 266.

Fig. 267.

making the flanges in the plan (Fig. 266) fast. Then the core-box, also, may be jointed in the same fashion, and its

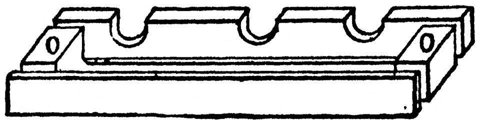


Fig. 268.

sides screwed fast to its body portion. See Fig. 268, which shows the parts of one-half the box made in this fashion, ready to go together.

The barrel (Fig. 269) is turned as a cylinder pattern would be, from solid stuff if of small bore, or lagged up if large—in each case jointed and dowelled, and having prints, *a*, *a*, at the ends. Where an aperture and door are made at the front of the lower end, as is done when the valves rest upon the top of a suction-box, the square portion of the D-shaped block is either worked from the solid or else as a separate piece of wood, and fitted over the main body. The core in that case is struck up by a board and shouldered down as shown at Fig. 270 to receive the D-shaped core, which is threaded on as the square base of a column is threaded on the round shaft

core (Chap. XVII., p. 201). Or the main core is struck to its full diameter, and a saddle piece made from a box of the section of Fig. 271 is fitted against it (Fig. 272).

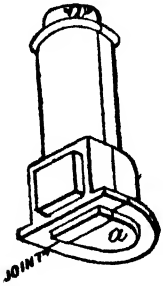


Fig. 269.

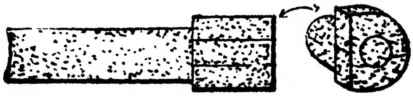


Fig. 270.

Fig. 271.

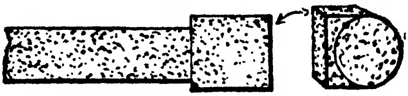


Fig. 272.

The bucket is made as shown in Fig. 273. The piston is turned from the solid, and the arch built up in about three thicknesses of small segments. The arch is fitted to the bucket itself by loose tenons or dowels. The water aperture

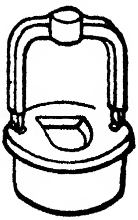


Fig. 273.

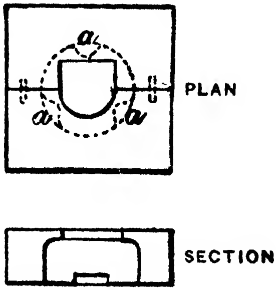


Fig. 274.

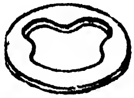


Fig. 275.

is better cored than cut out, the pattern being printed on the bottom, and its core-box (Fig. 274) being made in halves. The three lugs, *a*, *a*, *a*, in the bottom of the bucket are for the attachment of the cup-leather guard, shown at Fig. 275, which last is turned and worked from a bit of solid mahogany.

Air-vessels are cored out, the core being struck up. A core-box is only made when several similar castings are required. Frequently for large castings a loam pattern is used for the

body itself. The common form is the dome shape shown in Fig. 276, the pattern being jointed to mould sideways, and except at the print end the core rests upon chaplets.

The last of a series of suction-pipes is furnished with a strainer (Fig. 277) at the bottom, to prevent the entrance of any foreign obstructions with the feed-water, which would choke the pump. These pipes are constructed similarly to the air-vessel, but no provision is made in the pattern for the strainer holes. These, numbering several scores in a strainer of moderate size, are made in a peculiar way. The core-box is like Fig 278, its thickness being equal to the thickness of

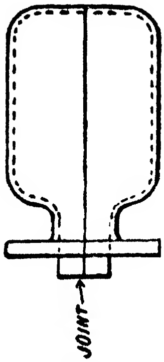


Fig. 276.

Fig. 277.

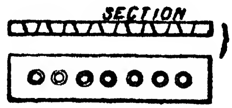


Fig. 278.

Fig. 279.

metal in the strainer bulb, and the holes have a large amount of taper. After being cut with a gouge they are burnt smoothly with a taper iron, its taper corresponding with the taper of the holes. The cores are then rammed up, each with a common cut brad standing point upwards from its centre (Fig. 279). When dried, the cores are stuck around the mould, approximately equidistant, by means of the brad points thrust into the sand. The main core is then laid in, and rests upon these cores, so that chaplets are not requisite.

Sluice-cocks comprise shell, cover, plug, and screw parts. The shell and the plug only need be mentioned. The shell (Fig. 280) may either have flanged or socketed branches—the latter being the more convenient for jointing up. The way of jointing the pattern is not affected, whichever form of branch we make. I have made these with the sockets up and down, and of course left loose (indicated by the dotted lines in the elevation); but this involves putting in the core

in three portions—first, that for the bottom socket; secondly, the body; lastly, the top socket—and is therefore not to be recommended. The cheaper way is to joint through the centre of sockets and body as shown in the end view, and so mould the cock edgeways. Then the core is made all in one, as represented in the plan of the open box, and time is saved both in pattern-shop and foundry.

In small cocks the brass facings are cast in a piece with the shells. The facings being cast first in brazing metal with projecting nipples (Fig. 281), are turned bright and laid in

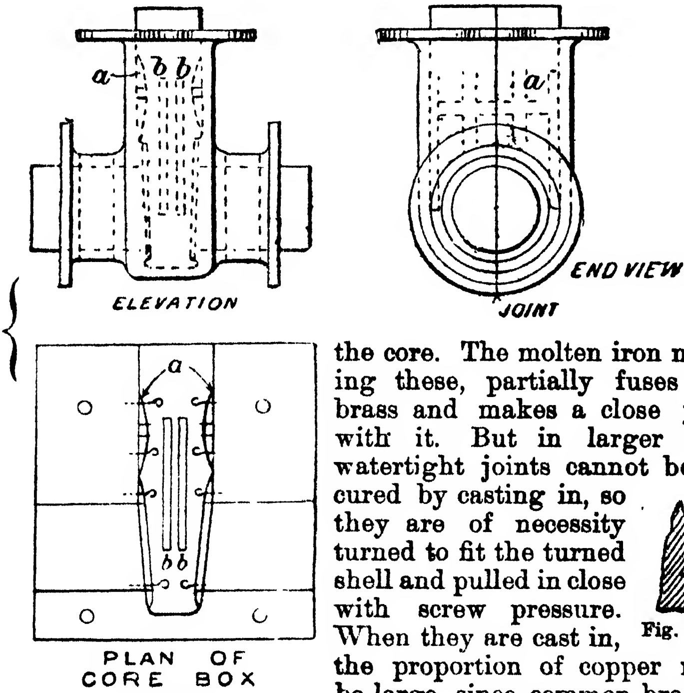


Fig. 280.

the core. The molten iron meeting these, partially fuses the brass and makes a close joint with it. But in larger ones watertight joints cannot be secured by casting in, so they are of necessity turned to fit the turned shell and pulled in close with screw pressure. When they are cast in, the proportion of copper must be large, since common brass or gunmetal would melt at the temperature of molten iron. From 4 inches to 6 inches in diameter is about the limit at which a perfect amalgamation of the metals at the joint can be relied on.

Fig. 281.

By making the pattern as we have indicated there are no loose pieces required. In the core-box the only loose pieces are the circular facings which carry the brass rings, and also in large cocks the internal strengthening ribs, *a*. The guide-

strips for the plug, *b*, *b*, are fastened in the top and bottom of the halves of the box.

The plug pattern (Fig. 282) is made from the solid, and is turned without, and recessed down on each side to the central web, *a*. On this web boss pieces, *b*, are fitted, to give the metal round the central hole, *c*, which is large enough to allow of clearance for the screw. A block for the nut, *d*, a print, *c*, at the bottom end of the same size as the central hole, and a couple of guide strips, *e*, *e*, skewered on, complete the pattern. The remarks made in reference to the facings in the shell apply to those on the plug. The core-box for the hole has also a recess cut in it similar to the recess cut in the saddle of a lathe to carry the screw-nut.

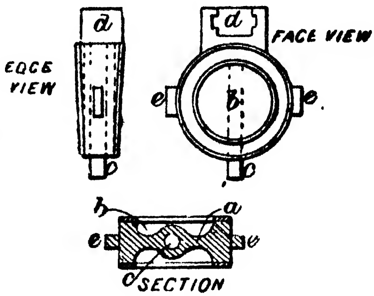


Fig. 282.

The nut (Fig. 283), made of brass, is, instead of being screwed in the lathe, commonly cast upon the thread of a duplicate of the screw itself, three or four such being cast upon one thread at a time. The screw rests in a bed made in the sand by a long pocket print shown in Fig. 283), *a*, *a*, *a*, *a*, which print is of course "stopped over" against the face of each nut.

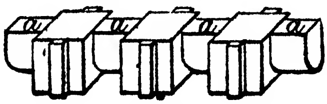


Fig. 283.

Force-pumps, unless when very small, are seldom made from

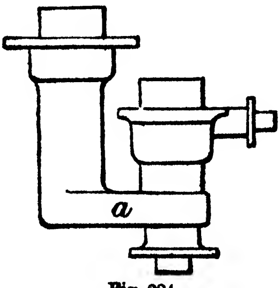


Fig. 284.

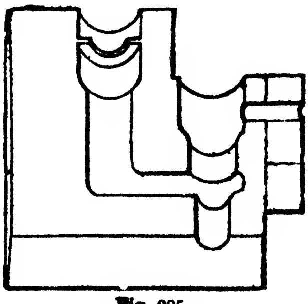


Fig. 285.

solid stuff, because of the liability of the timber to curve and twist. Fig. 284 shows such a pump, in which the turned

portions are each made separately, and screwed to the rectangular part, *a*. One half the core-box is shown at Fig. 285, and the stuff of which it is composed is prevented from curving by battens screwed upon the back.

In working a core-box of this kind it is not necessary to make templets for each separate radius. A set-square furnishes a convenient and certain means of checking the accuracy of a semi-circle, since, if the edges touch the opposite sides of the diameter while the corner is in contact successively with every intermediate portion, the conditions of a true semicircle are fulfilled (Fig. 286).

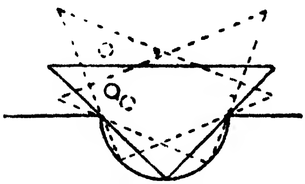


Fig. 286.

In making gland and bib cocks, and similar articles, it is better, unless they are exceptionally large, to cut them out of the solid, and this remark applies to the generality of small brasswork. Of course the parts which are spherical can be turned, even though they occur in different axes, by re-chucking, and the portions intermediate worked by gouge and chisel. Moreover, jointing is not commonly resorted to in these patterns. The regular makers seldom joint small work at all, but use bottom boards, and also use metal patterns largely. In places where these things are a speciality, there will be as many as a dozen, or twenty or thirty, of such separate and distinct metal patterns, usually of brass, in a single box. It is marvellous to note the rapidity with which the workmen will lift the patterns out one after another with their fingers, without disturbing or breaking down the sand in the process. But it is essential that the metal patterns be got up well, and that the core-boxes—also of metal—be well jointed.

It is not customary to mark out both halves of a core-box with compasses and square. One-half only is usually marked first and worked. Its face is then either chalked over or smeared with red lead, and the unmarked half pressed closely against it and tapped with a hammer, when the lines of the bounding edges will be transferred by the chalk or red lead to the opposite face. Or where easily got at, a bent scriber is brought into requisition, and being carried round the edges, marks the lines on the opposite half.

The pattern for a common globe-valve (Fig. 287) might be jointed in the plane of the figure (vertical section), and be either worked out of a solid piece, if of small dimensions, or,

if large, the globular part would be turned, together with the inlet and outlet ends and their prints—the branch for the screw-gland being turned separately and fitted on. Or the pattern might be jointed at right-angles to the plane of Fig. 287—that is vertically, line A, B—and the branch be moulded downwards; and this I consider the better way, as more convenient for laying in the cores. A small valve has usually nut-shaped hexagonal ends as figured, and is screwed within with gas-taps for the attachment of the piping. But large valves often have flange attachments, both at the ends and on the top, and in the latter case the top flange will be left loose if the branch is moulded downwards. The core for a large cock is not made in one, but in two pieces. The cores are

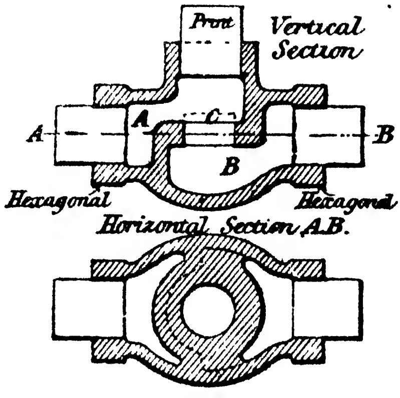


Fig 287.

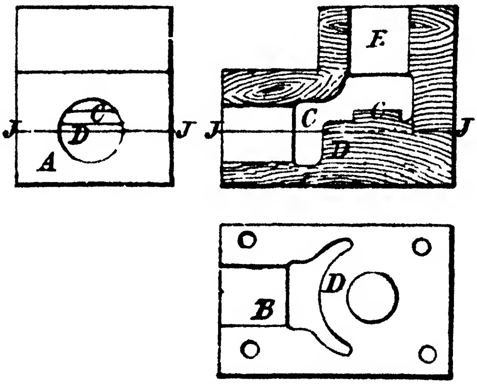


Fig. 288.

made from two separate boxes, and fastened together with claywash before being put into the mould. Looking at Fig. 287, A is one core and B is the other, and they are connected together by the print C, shown dotted in the figure. In setting to work, just dismiss core B from the mind for awhile, and start about making a box for A. Three views

of the box are given (Fig. 288), A showing its appearance viewed from its outer end; B, in sectional plan, looking on the face of the core-box joint and downwards; C, a sectional elevation cut longitudinally through the box. Clearly the box parting at the joint, J, allows perfect freedom of delivery for the semicircular portion, D (Fig. 288), and also for the branch part, E, and the print, C will leave a recess in the core, by which core B may be set true. Now make a box for core B, jointed at J, which is

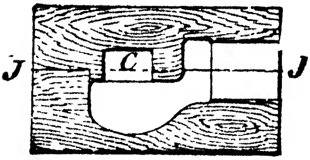


Fig 289.

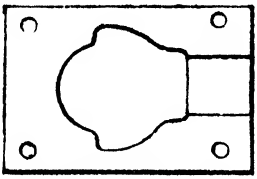


Fig. 290.

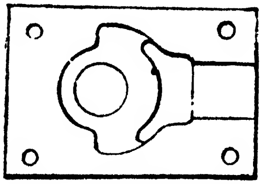


Fig. 291.

(Fig. 289) a longitudinal section. It is shown in plan in the joint, looking downwards, at Fig. 290, also looking upwards in Fig. 291. Evidently now the stud, C, formed in this core will drop into the print in core A, and the two cores together will in section be like Fig. 292, which is exactly what we require. This is the way adopted in making cocks of moderate and large dimensions. In very small cocks, however, say of 1 inch or thereabouts, it is often deemed not worth the while to round the metal outside the valve-seat, and then one core-box suffices. Its plan would be like Fig. 293, and its section, of course, as before; and the joint of the box would show like the vertical section of Fig. 287.

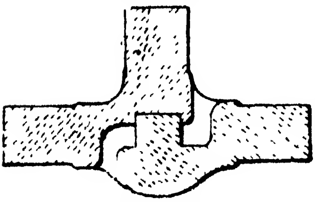


Fig. 292.

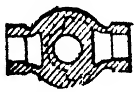


Fig. 293.

CHAPTER XV.

COLUMNS AND PIPES.

Jointing of Columns and Pipes.—Lagging up.—Turning.—The Use of a Steady.—End Flanges.—Body Flanges.—Socket-pipes.—Putting Holes in Flanges.—Loam-pipes.—Fitting Branches.—Throat Core-boxes.

MAKE it a rule to joint all columns and pipes, whether they be large or small. Jointing the pattern prevents the tearing away of the upper half of the mould, and the joint forms a convenient basis for the marking of centre and parallel lines, the setting square of blocks, facings, flanges, bosses, &c. Pipes and columns up to 7 or 8 inches in diameter will be made of solid stuff; if they exceed those dimensions they should be "lagged up" (Fig. 182, p. 131). The transverse blocks or bars upon which the lagging is to be laid may be about 12 inches or 15 inches apart, so that in a long pipe or column there may be as many as a dozen of transverse blocks, and each bar should have a dowel in the centre. The number of pieces of lagging which form the circle will vary with the diameter of the pipe or column. An 8-inch pipe may have eight strips to the circle, while a column of 16 inches or 18 inches diameter may have a dozen. Fit the strips and glue successively in the manner described when treating of engine cylinders,* the only difference being that a long joint is not made to fit close so readily as a short one, and may require to be chalked and tried in place repeatedly before a fit is obtained. When built up, secure the two halves of the pattern with centre-plates (Fig. 212, p. 155), and put into the lathe. If the pipe be long, staple the joint at intervals before attempting to turn. Do not turn any one portion to finished sizes immediately, but rough the whole pipe down from end to end first. If other work can be prepared in the

* Chapter IX., p. 130.

interval, it is even better to let it remain thus roughed down for a few hours before finishing than to finish at once. The reason is, that all timber, whether well seasoned or not, has a tendency to spring, and will in most cases buckle more or less out of its original shape when newly-cut grain is exposed to the air. For this reason a careful workman, when beginning a lengthy job, always "gets out" as much stuff as he can see his way clear to prepare, and "jacks" it all over before planing or turning any one portion to its finished dimensions.

If the column or pipe be of small diameter relatively to its length, it will vibrate or "wobble," to use a workman's term, in the lathe, so that to turn it true will be impossible. Make a steady, shaped roughly to fit the bed of the lathe and to take the diameter of the pipe. The sketch, Fig. 294,

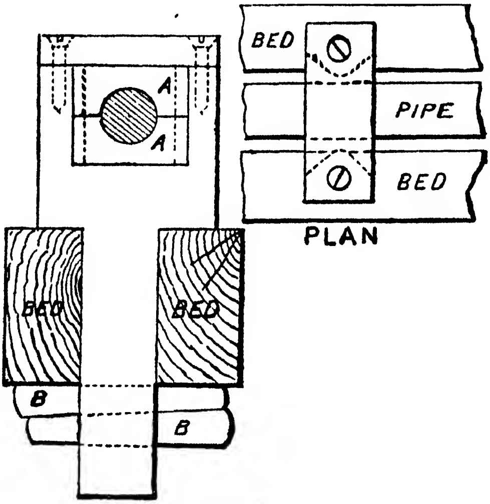


Fig. 294.

shows the best way to make a steady. By means of the sliding blocks, A, A, replaceable at pleasure with blocks of any other dimensions within the limits of the Vee'd portion of the steady, we can make it a standard tool for pipes of various dimensions. Wedge-shaped cottars, B, B, passing through the shank, will hold it firmly in position on the bed. A lubricant must be applied where the pipe runs in the steady, else much heat will be developed, and an excessive amount of friction be set up. Soft soap, or soft soap mixed with blacklead, are good lubricants.

It will facilitate the operation of turning if, in a long pipe, after having reduced the two ends to the required diameter, we plane a straight flat along the pipe from one of the finished ends to the other. We can then see at a glance, when working at any portion of the pipe, whether we are nearly or quite down to the size, without having recourse to calipers and straightedge continually.

Flanges, round, square, or of other shapes, socketed or spigoted ends, belts, mouldings, &c., will be required for pipes and columns. If the pipe is to be flanged, the flanges will be made distinct from the body of the pattern. A flange will be made in halves, dowelled together; and where it is put on at the end of a pipe, the hole must be made of such a size that it

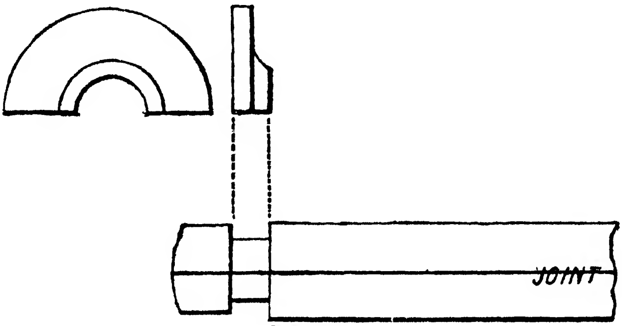


Fig. 295.

shall drop into a groove somewhat smaller in diameter than the print, to keep it steady. If the print at the end of the pipe is, say, 4 inches, the groove may be 3½ inches in diameter (Fig. 295). The stuff should be got out thicker than the actual thickness of the flange, to allow of a small radius or hollow being turned out at the back. If the casting is to be faced, ⅛ inch must be added to the thickness on the front side of the flange on that account. If the flange is to go on some part of the pipe intermediate from the ends, it is usual to turn it as a "body flange"—viz. a flange having a hole of the same diameter as the *outside* of the pipe, Fig. 296. The flange can then be slid along and screwed to any desired position, and the casting can be "stopped off" to the corresponding length. In body flanges the hollow on the back is usually omitted, being left for the moulder to rub in sand.

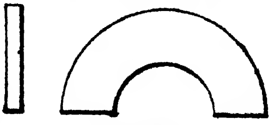


Fig. 296.

For socket and spigot pipes, or faucet and spigot, as they are also called, the pattern may have blocks glued upon it just where the socket is required, large enough to bring it up to the proper size, and long enough to include the socket print, which, of course, will be larger than the outside of the pipe by the necessary allowance for "caulking." This method of blocking up the pattern with a permanent socket, though proper enough for standard work, would be absurd in a jobbing shop where pipes of all lengths and of both kinds—flange and socket—are made from a single 9-feet length of pattern. We must have the socket, like the body flange, a thing quite distinct from the pattern, to be screwed on anywhere or removed at pleasure. The most convenient form is an iron pattern socket in halves, fitting over the body of the pipe, and cast very thin to reduce its weight. A single screw run in from the top holds it in position (Fig. 297); dotted lines indicate how the socket is lightened out. For the spigot a bead of lead may be cast, bent round, and tacked to the pattern, or, if for permanent use, it may be turned out of the solid.

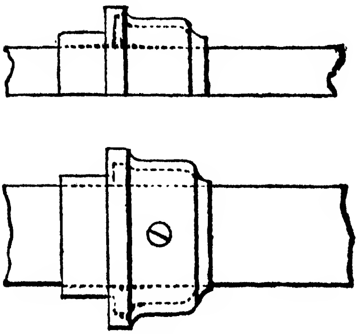


Fig. 297.

When round or square holes are cast in flanges, they should be put in by templet; in this case a piece of thin wood cut to the shape of a half flange and having slot holes cut out, the termination of those holes giving size and position of cores.

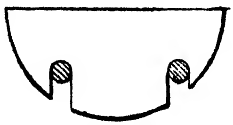


Fig. 298.

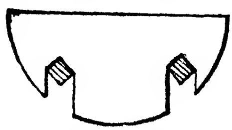


Fig. 299.

The cores, rubbed to the thickness of flanges, are thrust into position by the templet, and the slight friction of their faces against the faces of the mould is sufficient to retain them in place during the inflow of the metal. Fig. 298 shows a templet flange for round, Fig. 299, one for square holes.

Pipe patterns from which a large number of castings are required are always made in wood or (where the quantity is very large) in iron. Yet we sometimes have pipes of a large size to make where the number of castings is not sufficient to pay for the cost of a pattern. In that case we make a loam pattern. That is a different thing from a loam mould. In the latter case our boards are made to strike the actual *mould* (Chap. X.). In the former, the boards strike up the *pattern* from which the mould is to be made. The flanges will not be struck up, but made in wood, unless, indeed, they happen to project but a short distance from the pipe body. Mouldings and sockets, however, will be struck as part of the loam pattern. The annexed figures (300) will

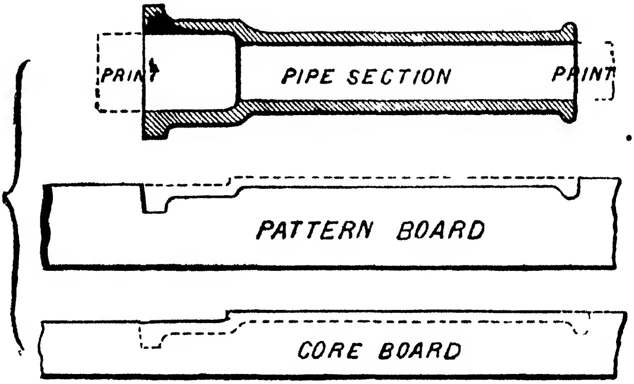
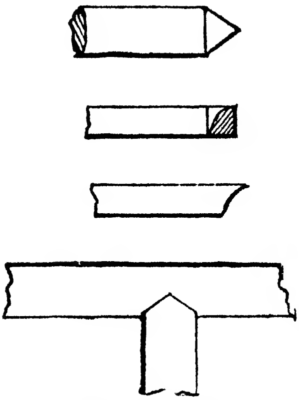


Fig. 300.

sufficiently illustrate the way in which a loam pattern and its core are struck up, without verbal explanation. We shall return to the subject of loam patterns again in connection with some more elaborate forms of work.

Branch pipes, fitted to a main piece of pipe, might have their ends struck out geometrically; but we can always, or almost always, chalk the main pipe and cut the branch to a fit in less time than would be occupied in striking the necessary lines. Where branch and pipe, however, are of the same diameter, there is a ready and simple method of insuring a fit at once. Having marked in the joint of the branch the line where it is intended to abut the edge of the pipe (Fig. 301), on this, as a base line, construct a triangle, whose sides shall be inclined towards it at an angle of 45°, meeting con-

sequently and forming the apex at the centre line of the pipe. Cut to these lines at right angles with the joint (Fig. 302). Where the cut faces intersect the circumference of the branch, a curve will result, which, if worked to, will insure the required fit without further trouble (Fig. 303).



Figs. 301, 302, 303.

Fig. 304 shows a tee pipe, or tee piece, made in the usual way, with a wide throat at the point of junction, for the purpose of allowing freedom of water way, and diminishing friction. Here a special core-box (Fig. 305) is advisable, to get the throat of the shape corresponding with the pipe. The core for the pipe, being plain and circular, can be struck up separately, and the branch core abutted against it in the mould. These throat

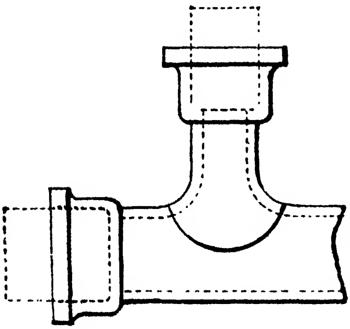


Fig. 304.

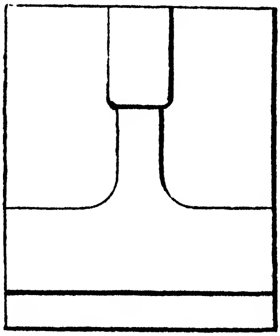


Fig. 305.

core-boxes are made for various sized pipes, and kept in the pattern stores ready for use. Long cores of small diameter, used frequently when casting columns, are often made by winding tow or rope round an iron pipe to which the requisite amount of prepared loam is then applied. A board having the desired profile, a " striking " board, is then brought into contact while it is rotated, thus the core is given shape.

CHAPTER XVI.

MISCELLANEOUS PIPE-WORK.

Turning Quick Bends in the Lathe.—Working Flat Bends.—Dovetailing Bends.—S-pipes.—Striking up in Loam.—Guide-line.—Guide-iron.—Strickles.—Sockets.—Pipes of Irregular Shape.

COMMON pattern bends of uniform section can be very conveniently turned in the lathe if we want two bends of the same size. Jointing four pieces together at angles of 90° and screwing them on the faceplate, we can turn the semicircular section with a templet in far less time than would be occupied

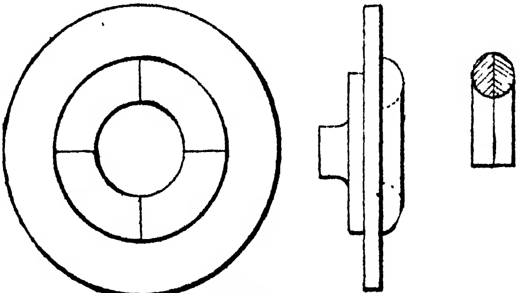


Fig. 306.

with gouge and chisel and spokeshave, and with more accurate results (Fig. 306). Removing the four half patterns from the faceplate, we dowel them two and two together, forming two bends.

If the pattern is of a flat curve, as in the common "eighth" and "quarter" bends of the pipe-makers (Fig. 307), or if it is a "reducing" bend, viz. a bend tapering from a larger to a smaller bore, the use of the lathe is out of the question. In these cases we joint truly together two pieces of wood large enough to take the outline of the bend, each piece being thick enough to take half the diameter of the bend. We dowel

them together, and on the joint face of one mark the outline we require. Cutting to these lines we obtain the longitudinal form, and working with gouge, chisel, and spokeshave, guided by a semicircular templet, we get the transverse section. We mark the outline of the second half from the one just worked,

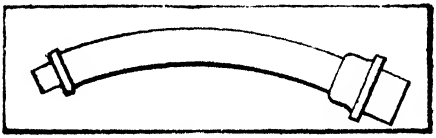


Fig. 307.

and cut that in turn with the half templet. Socket, bead, and prints are put on afterwards.

Some workmen have a way of cutting a bend, which, though slow, is safe, because there is no risk of undercutting, as there is sometimes where the roughing down is done recklessly before a templet can be tried on. It is to work the stuff, first of all rectangular in section (Fig. 308), gradually

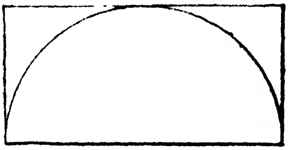


Fig. 308.

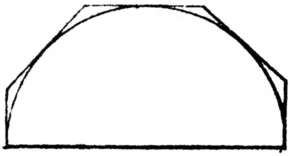


Fig. 309.

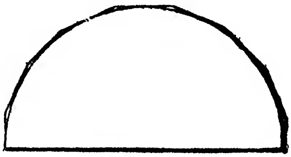


Fig. 310.

into a polygonal form until a nearly circular section is attained (Figs. 309, 310). The last remaining angularities being taken off with a spokeshave, a practically true circle is the result, which will not show wavy lines in the longitudinal direction. This is certainly the better method to adopt with a *reducing* bend, in which the diameter is constantly varying.

When the pattern is to form the elbow of a bend pipe (Fig. 311), it is necessary to attach the straight pieces of pipe each to their proper end of the curved portion. This we shall effect by means of a double dovetail, which is to be let into

each of the portions of pipe which abut against one another (Fig. 312).

Sometimes pipes are made of very awkward shapes, to curve round parts of machinery, buildings, other pipes, &c.

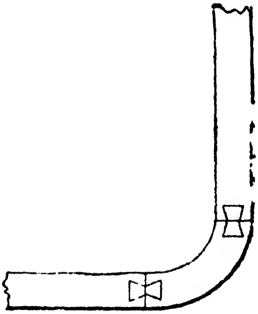


Fig. 311.

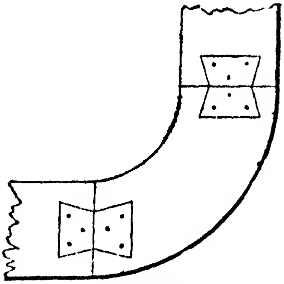


Fig. 312.

There may be two or three different bendings of the pipe not all in the same plane, and the flanges may have their faces at angles other than right-angles relatively to the axes of the pipe. The pipe-makers supply bends and S-pipes of various shapes, by which the desired shape can often be pieced up; but where space is limited, or where a graceful outline is wanted, we make a pattern; and this opens up the question of loam work. In these and many other cases we want but one casting, and if the pipe is of large or even of but moderate dimensions, the pattern would cost a great deal more than the casting itself. Then the question of wood *versus* loam becomes one for our consideration. In large castings the answer must be in favour of loam in almost every case, and in small castings also it will usually be cheaper to strike up the pattern in loam. But in those awkward-shaped pipes, such as Fig. 313, where the bends are not in the same plane, it costs less to knock out a rough unjointed pattern in wood than to strike it up in the foundry. Yet even in a case like this, if the casting were large, say over 6 inches in diameter, loam might be the cheaper.

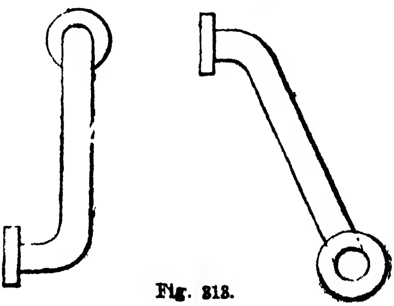


Fig. 313.

The beginner, however, must remember the rapidity with which complicated forms in wood can be produced, as a glance at Fig. 109A and Chapter XXIX will show. Certainly, to strike up a pattern in loam would be cheaper than relying upon, say, a slow mechanic working with ordinary joiner's tools.

Nevertheless, while it is necessary to be acquainted with methods old and new also, it must be remembered that there still exist small foundries who apparently make these old methods pay, the process of striking up a pipe in loam will therefore be described. In pattern-making it frequently happens that, though the parts which the workman has to prepare for the moulder's use are few and simple in form, they involve more technical knowledge than work of more pretentious appearance. This is especially

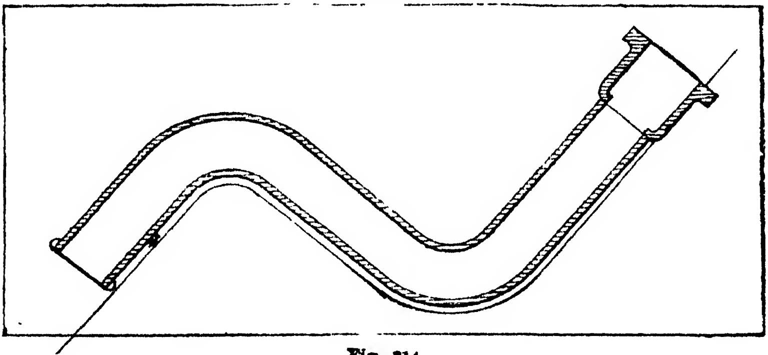


Fig. 314.

the case in loam work. The parts which the loam moulder requires are few and simple, and, like many other things, they are easily made—when one knows the way.

Let us commence upon the drawing. Fig. 314 represents the board, upon which we have drawn a 6-inch S-pipe in longitudinal section. Observe that there is a line drawn parallel with one side of the pipe, and at a distance of ¾ inch away from its edge. This is the "guide-line." We mention ¾ inch, not because that dimension is of any importance—it might just as well have been ½ inch or 1¼ inch—but the better to illustrate our explanation. By this line the foundry-smith bends a piece of ½-inch or ¾-inch square rod, which becomes, as we shall see immediately, the "guide-iron" (Fig. 315) for the "strickles." The strickles are the templets used for striking the transverse sections of the pipe in loam, and they have their edges cut in such a way that each strickle is

maintained at its own proper distance from the guide-iron during the process of striking. Thus, the guide-iron being $\frac{3}{4}$ inch away from the body, the body strickle (Fig. 316) will be notched up $\frac{3}{4}$ inch from one edge of its 7-inch semicircle.

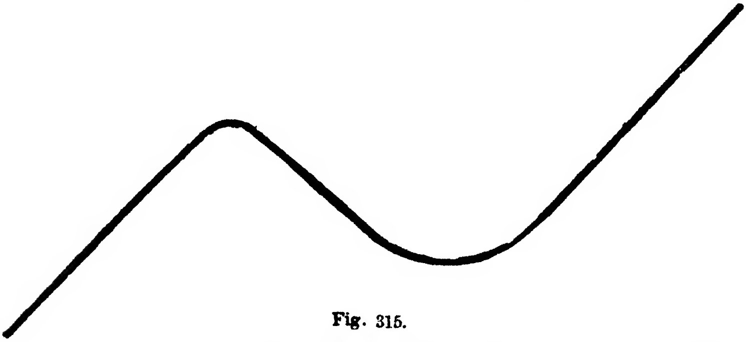


Fig. 315.

But the metal in the pipe being $\frac{1}{2}$ inch thick, the core strickle (Fig. 317) will be $\frac{3}{4}$ inch + $\frac{1}{2}$ inch = $1\frac{1}{4}$ inch wide at the shoulder. The edge of the strickle is chamfered like that of a loam board (Fig. 318). These strickles are used thus:—The

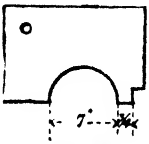


Fig. 316.

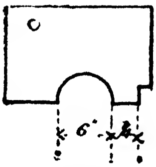


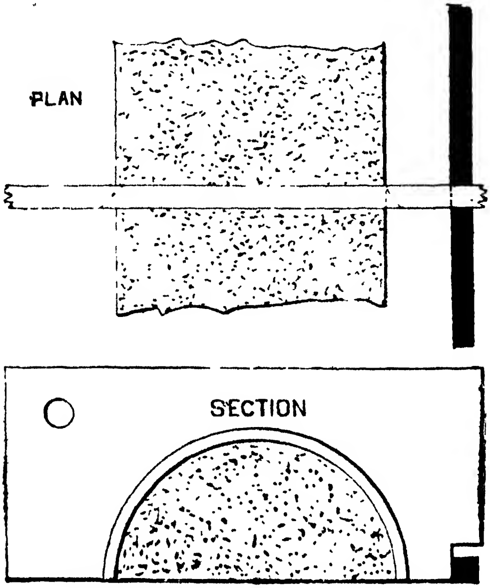
Fig. 317.

Fig. 318.

guide-iron is laid upon a plate on the foundry carriage, and kept in position by sundry weights resting against it. Then the "check," as it is called, of the core strickle (Fig. 317) is set against the guide-iron, and a semicircular body of loam is struck up (Figs. 319), following, of course, the contour of the guide-iron. The iron is then turned over and fixed again in a new position, and a similar half-core struck up, but the reverse hand to the first. These are run into the stove and dried. When dry, the *pattern* strickle is set against the guide-iron, and a thickness of loam struck over each half-core in turn. This also is dried; then both halves are detached from the plate, turned over joint to joint, and the rough pattern is complete (Fig. 320). A little touching up of the joints and a coat of tar will make it fit for the mould. After having been moulded, the thickness of loam representing the $\frac{1}{2}$ inch metal

will be stripped off, and the core placed in the mould for casting.

If a flange is required for a loam-pipe, the hole in the flange will be of the same size as the core, and the body thick-



Figs. 319.

ness of loam will be shouldered back to afford steadiness to it. Obviously, a socket end would not be formed with strickles very readily, on account of the dressing off necessary where one diameter blends with another. Hence sockets are in most cases struck separately in the same way that a straight piece of pipe would be, but on a body of loam equal in diameter to that of the pipe for which they are intended, to be afterwards sawn longitudinally down the centre and slid or threaded over the pipe body. They are held in place during moulding with nails. The socket-core is either treated in the same manner or abutted against the body core.

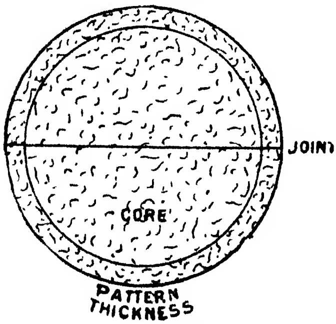


Fig. 320.

If we require pipes or hollow castings whose shape is not symmetrical, and which cannot, therefore, be struck on a revolving bar, or continuously by means of strickles, the difficulty is first how to get the core of the proper shape, and then how to insure an equal thickness of metal throughout. Take, for illustration, a reducing pipe connecting a rectangular valve-box or pipe with one circular in section (Fig. 321). Except at the ends the section is never uniform, so, except at the ends, a strickle or strickles cannot be used. In such cases the core body is first roughed up with a square strickle at one end and a round one at the other, and dried, then *rubbed* to its

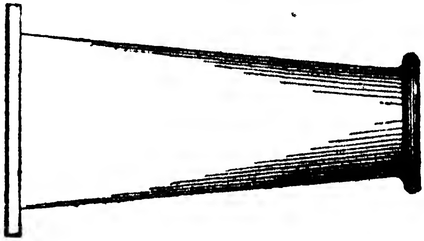


Fig. 321.

required shape with rasps and glasspaper. A number of strips are then prepared of the same thickness as the metal in the pipe. These are laid flat on the core in various positions, and their interstices are filled up with loam, which is strickled off level with their thicknesses. When the loam has set a little, but not baked, the strips are taken away, their vacant places filled up with more loam, and dried. When moulded, the thickness is stripped off as before, and the core placed in the mould.

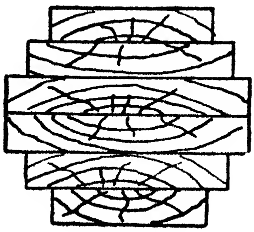


Fig. 321A.

The Correct Arrangement of Timber when Building up for a Pipe Pattern. Adjacent planks should have their annular rings curving in opposite directions.

CHAPTER XVII.

FLUTED AND ORNAMENTAL COLUMNS.

Apparent Difficulty of Moulding.—Number of Joints.—Central Foundation or Base.—Mouldings.—Flanges.—Working the Flutes.—Loam-board.—Square Core.—How attached.—Lines of Jointure.—Danger of Undercutting.

THESE, at first sight, would appear to present insuperable difficulties in the way of moulding. Looking at an architect's drawing, which somehow always does look more elaborate and enigmatical than the actual thing it represents, we wonder how such a complicated mass of ornamental work is to be got out of the mould. The pattern can be made like the drawing, but how to reproduce it in the casting is the difficulty. The use of drawbacks would perhaps appear feasible at first; but a little consideration usually reveals practical difficulties in the way of their adoption, and in most cases we are reduced to the method of loose pieces, as being, on the whole, the least troublesome.

We take, then, a fluted column like that shown in Fig. 322. Here we have a square base with mouldings, above that a fluted portion, then moulding again; after that a long fluted shaft, surmounted by an ornamental capital. It will be observed that the column in this case varies very much in diameter, being nearly twice as large in the lower portion as in the upper. We must strike out the column to full size, first in longitudinal outline, indicating the thickness of metal by dotted lines, and then in cross sections, at A A, B B, C C, to show the flutes. To make the pattern, we want a steady foundation—not the actual pattern, but that on which the pattern is to be built. Upon this base the fluted portion will be laid in strips, which strips will be drawn in succession from the sand, after the base is lifted out. A glance at the section (Fig. 323), will make my meaning clear. Divide the

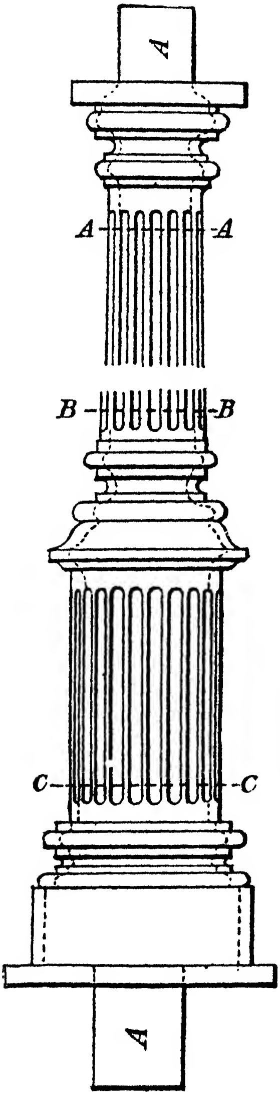


Fig. 322.

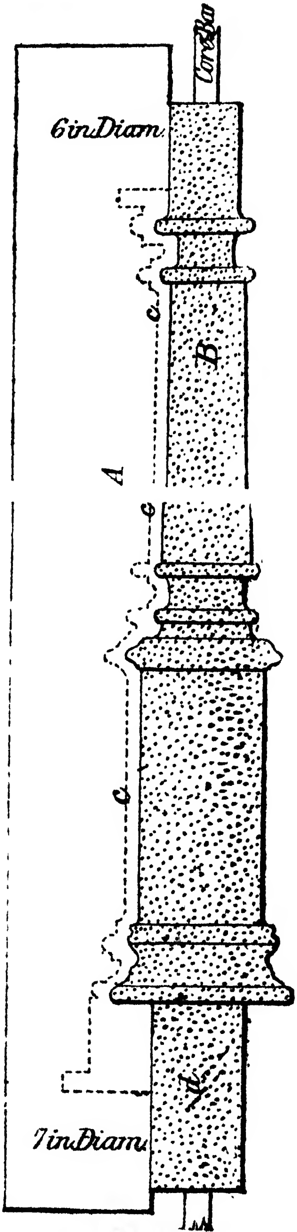


Fig. 327.

circle into such a number of parts that the flutes will draw readily from the sand; thus, a strip so wide as that shown in

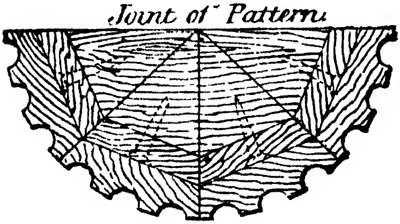


Fig. 323.

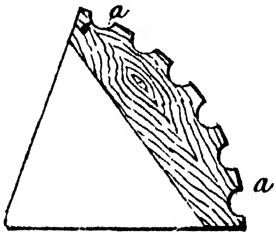


Fig. 324.

Fig. 324 could not possibly be drawn away without tearing down the sand at *a*, *a*. Let the edges, therefore, of the extreme flutings be plenty free enough, and do not, for the sake of lessening the number of joints, make the pieces so wide that opposite fluted edges will be *undercut* in relation to each other. There will not be less than six in any circle: eight are better, and in some cases twelve are desirable. We will have eight in this column. Divide the circle accordingly, and mark out an octagonal-shaped figure on each section to indicate the flat backs of the loose fluted pieces, allowing sufficient stuff at the bottom of the flutes for strength—say ⅜ inch or ½ inch. The central portion—that included between these lines—will be the base or foundation of the pattern. This may be solid if the column is not large, and if thoroughly dry stuff is available. But it is not advisable, in the case of a large pattern, to run the risk of its warping for the sake of saving the extra labour involved in jointing up; so we lag our central part up, just as in the case of a pipe pattern. This will contain the same number of lagging pieces as there are to be loose strips. At the lower portion of the long flutes (Fig. 322, B, B), the diameter is larger than at the top, so that unless we taper the body to an equal amount, the fluting stuff will be thicker at the lower end than at the upper. It is of no consequence which course we adopt. The lower series of flutes, however, are twice as large in diameter as the uppermost ones, and the loose pieces would be inconveniently thick and heavy to handle in the mould, if made of that extra thickness. Instead, therefore, of giving the extra thickness to these, prepare pieces of the same length, and of such a thickness as will reduce these flutes to the same substance as the upper ones, and screw them on the main body (Fig. 325).

This part, which forms the foundation for the column proper, should have good close joints, to insure the requisite rigidity; it should be as straight as possible, and each flat should be altogether free from winding or twist. Mark out lengths of flutes, positions of mouldings, and faces of flanges in the joint, and begin to build up.

Turn the mouldings first, jointing them, of course, in halves, with the grain running transversely to the axis of the column. Cut them out to fit over the angular body, or else groove out the body in the lathe just where the mouldings fit, and bore out the latter to fit in these grooves Screw the mouldings on from the *inside* of the column, since it is desirable that they should be left loosely attached to the body, to be withdrawn separately from the mould. Top and bottom flanges and square base will be prepared and fitted over similarly. Frequently small flanges are jointed diagonally, but in those of large size an inconveniently large moulding-box is rendered necessary; hence it is desirable to joint these latter parallel with their edges, and to put a little taper in their sides.

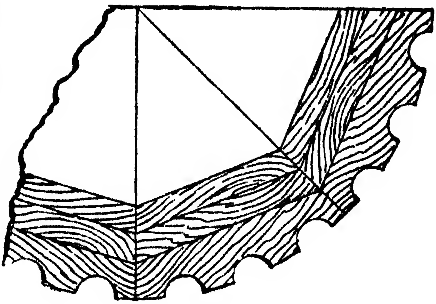


Fig. 325.

Then follow the flutes. As many flats as there are in the foundation body, so many separate joints will there be in the fluted portion. Each end of each flute will terminate in a hollow (Fig. 326). In preparing the stuff, square the pieces off just to the commencement of the hollows (Fig. 326, A, A). Screw on each end the narrow pieces, B, B, necessary to complete the length up to the mouldings. Then build up the strips in the usual way; instead, however, of gluing, screw (like the moulding) from the inside of the pattern. Afterwards work to a circular shape either in the lathe or with planes if no lathe long enough to take the pattern is available. Then the flutes will

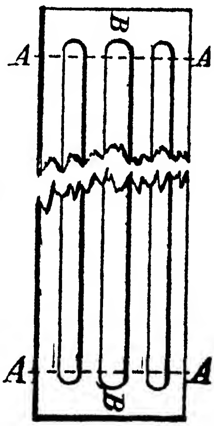


Fig. 326.

be divided round with compasses, and lined out with straight edge—the end make-up pieces, B, B, unscrewed, and the flutes worked along with a round-plane, after which the end pieces will be replaced, and their hollows worked with a firmer gouge and glasspapered.

The end prints, A, A (Fig. 322), are turned out of the stuff with which the column is built up, or else made separately and screwed on, dependent on circumstances. Sometimes, also, where columns are made in quantity, a certain portion of the length of the print, or an independent collar concentric with the print, is made to fit into a bored hole in the end of the moulding box while the pattern is being rammed up, and the core-bar has a collar also corresponding identically in size, by which a concentric position of the core relative to the mould is guaranteed. This, of course, applies to each end.

A round column with a square base such as ours is has a square core in that base, for which a special core-box is made, the round core being struck on a revolving bar. Fig. 327 shows the loam board which is used for striking the main core. A is the board, B represents the core, the dotted line, *c*, *c*, *c*, indicates the edge of the column, marked on the board to give the moulder his thicknesses of metal for the purpose of checking their accuracy when in the mould. It is usual to stamp diameters also at the ends as shown. Fig. 328 shows the box, in the centre of which a round print, *a*, passing through its entire thickness,

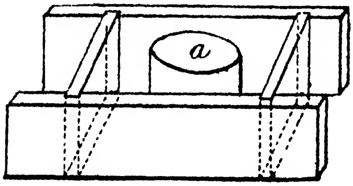


Fig. 328.

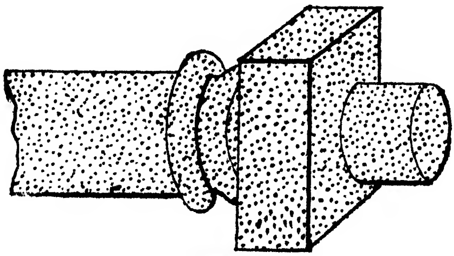


Fig. 329.

forms the hole, into which the shouldered portion of the long core (Fig. 327, *d*) is thrust (Fig. 329).

The foregoing remarks will enable the reader to understand the general process of column construction; but there is, as may be supposed, much variation of detail in columns of different designs. Still, the principle remains good in every case, so far as I know, that columns are not made by cores or drawbacks, but by *loose pieces;* and the one essential to be borne in mind by the pattern-maker is, that all parts shall withdraw easily from the mould. In highly ornate columns the pattern-maker is not required to do the carved work; but he has to joint the stuff in reference to the design, so that there shall be no difficulty in moulding after it leaves the carver's hands.

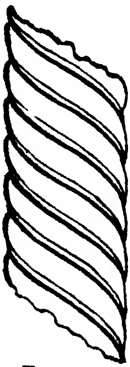


Fig. 330.

But it does not follow that a handsome column is difficult to make. A twisted design for a shaft (Fig. 330) does not involve any jointing at all, except the usual one in halves. Neither would an octagonal column like Fig. 331, excepting at *a*, *a* (section), where the undercut portion would be formed by two loose strips. Nor is it always desirable to joint radially from the centre, as in Fig. 323.

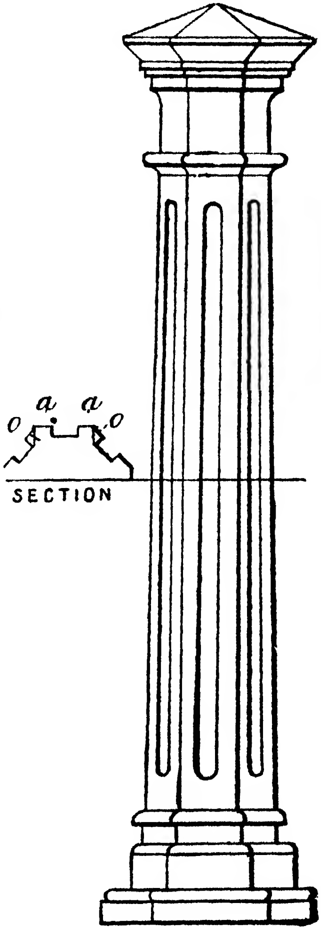


Fig. 331.

In that case, if the flutes had been deep, we should have jointed like Fig. 332, else the sides of the flutes would tear the sand away at *a*, *a*. When the central fixing reaching from *b* to *b* is lifted out, the side flutes, A, A, are drawn out parallel with the joints, *c*, *c*, after which the other two will follow easily enough.

Another mode of jointing some kinds of ornamental work is

shown at Fig. 333 (plan). Note that the central piece of the

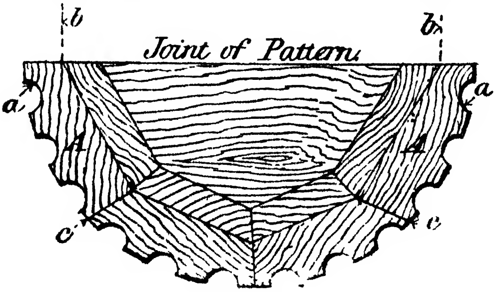


Fig 332.

pattern is somewhat wider at A, where the joint of the mould

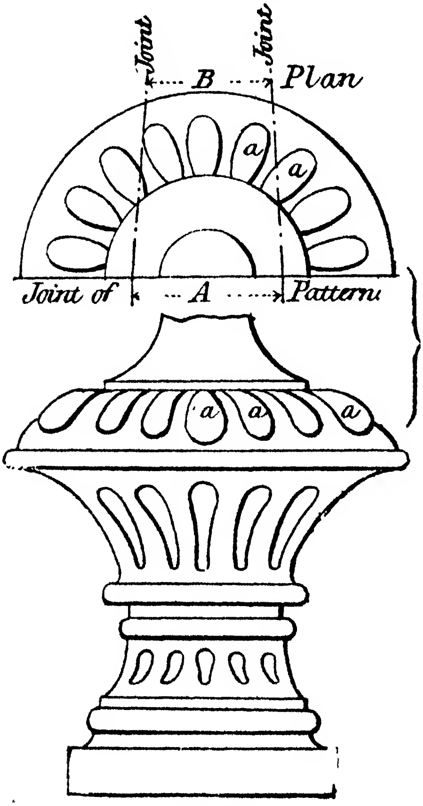


Fig 333

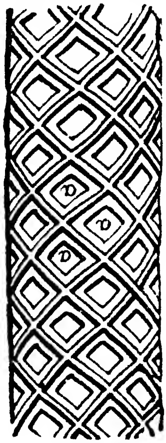


Fig. 334.

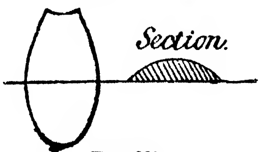


Fig. 335.

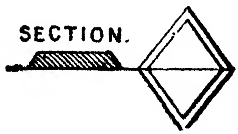


Fig. 336.

comes, than it is at B. This is for freedom of withdrawal from the mould, that piece being taken out first, the side pieces being removed afterwards. This joint is in frequent use, is easy to make, and allows of the side pieces being drawn away at any angle, even parallel with the joint of the mould—an arrangement possessing great advantages over the former in columns highly ornamented, such as those of Corinthian type.

In all columns and ornamental work generally this must be remembered, that no parts, however apparently insignificant, shall be *undercut*. It is more difficult to mend up work of this kind in the mould than any other; therefore, every little recess, flute, boss, swell, leaf, scroll, and moulding must have its edge so cut relatively to the direction in which it is to quit the mould that it shall cease to drag against the sand immediately that it is started by rapping. In doing this, it is sometimes, though not often, necessary to sacrifice a little of elegant appearance to the inexorable conditions of necessity. The undercut edges of the carver's work have thus to be tapered towards the outside of the pattern. But a little of this fudging will often save extra jointing, and the fewer joints there are in patterns of this kind the better: an experienced eye can always detect them in the castings. Looking at the swells, *a*, *a*, *a*, in Fig. 333, and the diamonds *a*, *a*, *a*, in Fig. 334, it would appear that they ought to be loosely wired on, and drawn out one at a time. But this would entail too much work. By fudging the carver's work, and tapering the edges (Figs. 335, 336), the main pattern joints make sufficient provision for the delivery of these. Even in working plain mouldings there should be *no absolutely square edges*, but a slight amount of taper should be given to every part.

"Stopping Off."—Certain foundries who specialise on column work find that, particularly with plain columns, a demand is often made for a length for which no pattern exists. In such cases "stopping off" is resorted to. Here one flange of the pattern is removed and replaced lower down the column to give the length desired. The unwanted end, of course, makes its imprint, but this is filled in with sand. This saves the cost of a new pattern, but can only apply to the *shortening* of columns. In anticipation of this the pattern-maker generally fixes the flanges so that they can be easily removed.

CHAPTER XVIII.

STRAP PULLEYS—METAL PATTERNS.

Curving of Pulley Arms.—Necessity of due Proportioning of Parts.—Rim.—Arms.—Boss.—Wood Patterns.—Iron Patterns: (I.) Made by Board and Core-box; (II.) By Sweep and Arm; (III.) By Ring and Set of Arms.—Split Pulleys.—Metal Patterns.—Why used.—Their Preparation.—Range of their Utility.—Road Wheel.

THE arms of pulleys, or of riggers (Fig. 337) as they are sometimes called, are usually curved, except in the case of those of very small diameter. This curving is considered essential in these light castings, lest the shrinkage of the boss, which remains hot longest after casting, should tear the too rigid arms asunder, either in the mould or at some subsequent period. Straight arms would be unyielding, while curved ones are somewhat analogous in character to a bent spring. For the same reason also the greatest care is necessary in properly proportioning the metal in the different parts—the boss, arms, and rim. To reduce the metal in the boss is the great essential. A heavy boss will infallibly break either the arm or the rim. If the rim is very rigid the arm will break, while if the arm be too strong the rim will break. In either case the mischief is due to the internal tension or stress set up through the contraction of the boss continuing after the rim and arms have cooled down and set. Hence, let the pulley be so proportioned that the boss shall contract very little after the other parts have cooled—so little that the moulder can counteract that small excess by opening the mould around it and allowing it to cool while the rim and arms still remain covered. Make the boss as light as possible consistently with safe working, and give the necessary strength for keying by adding a keyway boss (Fig. 337, *a*).

In proportioning pulleys, let the rim be from $\frac{3}{16}$ inch thick in small riggers to $\frac{1}{4}$ inch or $\frac{5}{16}$ inch in large ones, when turned. For pulleys running at a high speed give $\frac{1}{8}$ inch or $\frac{3}{16}$ inch

rounding per foot width of surface; for those running at slow speeds, say, ⅜ inch of convexity per foot. This rounding must be omitted in the pattern, except where it happens to be parted in the centre, care being taken, however, to allow sufficient thickness of rim to permit of the casting being turned to this extent in the machine shop.

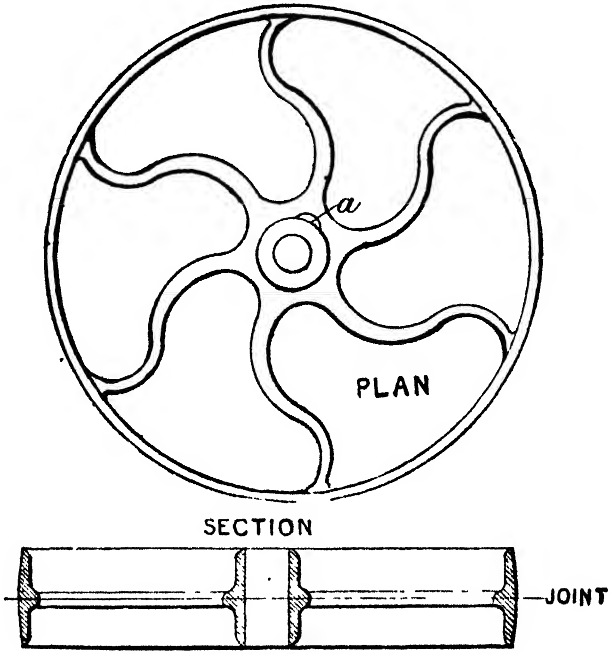


Fig. 837.

For the curves of the pulley arms set rules could be given; but many pattern-makers line out roughly with a pencil an arm which has a graceful appearance, and then adapt radii to it. In giving to the arms their *cross sections* a trained eye is almost or quite as safe as rules; but in the absence of experience the following rule gives correct results for pulleys doing ordinary work:—

$$\sqrt[3]{b} = \frac{d \times w}{n \times 8}$$

where b=breadth of arm at point,
d=diam. of pulley in inches,
w=breadth of rim in inches,
n=number of arms.

Thus a pulley 4 feet in diameter by 9 inches wide, having six arms, would have an arm 2 inches wide at the point. Near the boss the arm should be one-third wider than it is at the rim. Its section should be elliptical, and its thickness equal to half its width. If made thinner, the strength must be made up by cross ribs running down its centre (Fig 338).

The thickness of metal around the hole or eye is variable, depending upon the size of the shaft and the diameter of the rigger. A rigger on a small shaft will require less metal than the same rigger on a large shaft, because the torsional strain is less in the former case than in the latter. A large rigger will require more metal than a small one, because both torsional and centrifugal force will be greater in the case of the large than of the small one. Up to 2 inches or 3 inches in bore the boss is generally made twice the diameter of the shaft; over 2 inches or 3 inches a less ratio obtains. Practical men usually judge by the eye in proportioning a boss. A formula which gives a good boss is this:—

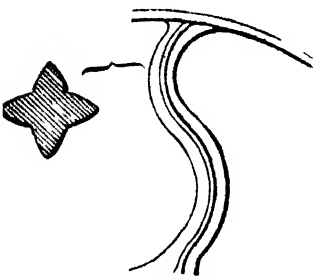


Fig 338

$$D + d + 5 = t$$

Where D = diam. of pulley in feet,

d = diam. of shaft in inches,

t = thickness in metal in boss in *eighths of an inch.*

The length of boss may be two-thirds the breadth of pulley, except in the case of fast-and-loose pulleys, where they should be a trifle longer than the breadth of rim, $\frac{1}{8}$ inch or thereabout. The keyway boss should be as thick as the depth of keyway, and embrace one-sixth of the circumference of the main boss.

Small strap pulleys are sometimes made from a complete pattern of hard wood, in which the rim is built up in segments, and the arms let in when the building-up process has reached to the centre. Owing, however, to the extreme lightness of these pulleys, wooden patterns are too flimsy and fragile for those of larger diameter or those intended for repeated use. Hence in usual practice we discard wooden patterns, and resort to as many as three other different methods of making pulley castings. The first and least commendable method is that described in connection with the flywheel with cast-iron

arms in a previous chapter, viz. that in which a board and core-box is used. Except for a makeshift and temporary job this is not to be recommended, not even for large pulleys, much less for those of moderate size. An iron pattern is far preferable, and is essential where there is a repetition of castings.

The iron pattern itself will be made either from a rough wooden pattern, just strong enough to hold together for the one moulding, or from a previously existing casting, or it may be struck up. If deep, it ought to be jointed in the centre of the arms, to afford better facilities for moulding (Fig. 337, section). An iron pattern in halves can be made very readily thus: a sweep, half the total depth of the rim, can be worked round to form the ring, and a single arm and boss, jointed down its centre, can be rammed up six successive times to form the six arms of the pulley. Two separate halves can be made in this manner, and be jointed afterwards to form a complete pattern. A pattern thus made must be dowelled, turned, and filed in the fitting-shop, and then varnished or beeswaxed, warm, before it is ready for the foundry. This is somewhat costly, but the first expense over it is, accidents excepted, imperishable, and free from the defects to which wooden patterns are liable, as warping, shrinking, and such like.

A third method is to have an iron pattern still, but in a modified fashion. There will be an iron ring (Fig. 339) repre-

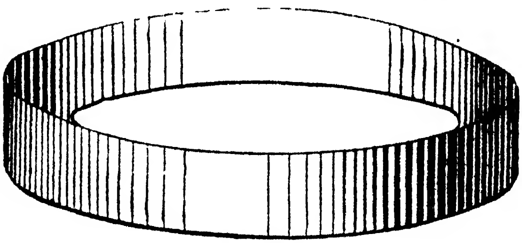


Fig. 339.

senting the pulley rim, turned inside and outside, but wide enough to embrace the widest pulley that may reasonably be expected to occur—say 12 inches to 15 inches. This will be made from a sweep in the first place. Also a complete set of arms distinct from the rim, with a hole in their centre for the reception of separate bosses of any required diameter (Fig. 340). The advantage of this latter method is that pulleys may be made off such a pattern of different widths, and with bosses varying in size to suit different-sized shafts.

These, of course, are expensive, but are everlasting, and extremely convenient for making pulleys of variable widths and bores. The inconvenience caused by the absence of a joint is got over by the moulder thus: He does not ram up the top box over the rim and arms, as in an ordinary pattern;

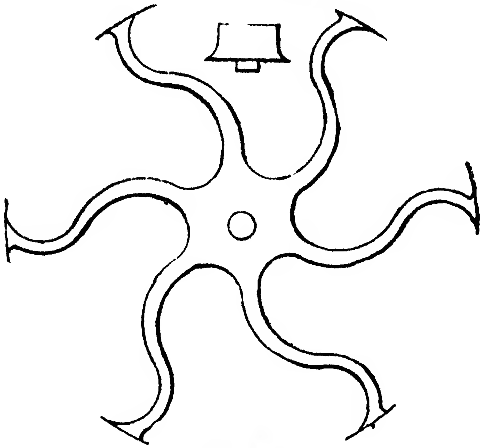


Fig. 340.

but using the rim and arms as a *core-box*, makes and lifts away two cores, top and bottom, to be replaced after the outside of the rim is rammed up. The necessary depth of rim is given by a strickle working down from the top edge of the rim.

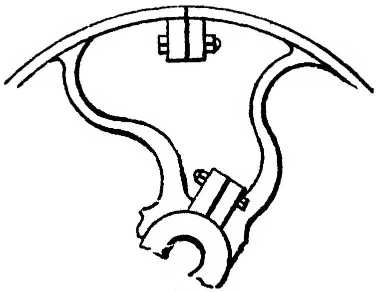


Fig 341.

Pulleys are often split for the same reasons that cog-wheels are split, when they are to occupy some intermediate portion of a shaft (Fig. 341). The same process is adopted as in cogwheels, blocks and prints and splitting plate pattern being required. The curving of the arms gives a rather unsightly appearance to the lugs on the boss, but it cannot be avoided, and is a matter of no real consequence.

Metal Patterns.—A few remarks on these, suggested by the subject now discussed, may fitly close this section. Patterns

are very often made of metal. They are so made when, from the flimsy character of the work, a wood pattern would get out of shape or become broken to pieces, or where the number of castings required is so great that a wooden pattern would not last long enough to mould the total quantity. In the former category may be classed all kinds of light and ornamental work; in the latter, almost anything of moderate weight.

If we make a pattern of wood from which to mould a metal pattern, we do not bestow anything like that amount of labour upon it which we should devote to one for standard use. We should neither build it up with a view to strength and durability, nor should we finish it so neatly. It will be made so that it might be moulded once, after which it is useless. But we bestow all our care on the metal pattern. We should turn it where circular, and plane, or file, or grind portions which could not be turned. If made of brass, nothing further is requisite; but if of iron it must be coated with some preservative against rust. Warm the metal and rub it over with a rag dipped in melted beeswax. This forms a glossy skin, and allows the metal to leave the sand readily; or varnishing with shellac varnish also answers very well. But to insure the adherence of the varnish on bright work it is necessary to rust the metal first. Wet it with a solution of salammoniac, allow it to dry, then glasspaper and varnish.

In making a wood pattern for a metal one *double* contraction must be allowed, since there will be the contraction of the metal pattern itself besides that of the casting to be allowed for.

The use of metal for patterns is not, however, restricted to iron and brass. Sometimes we want a curved casting, and various reasons would concur to render the working of wood patterns unadvisable—the attendant expense, the weakness of cross grain, the difficulty of marking out, and such like. Then we make a straight wooden pattern, cast it in lead, and bend it to shape afterwards. From this a more rigid iron pattern can be made if required.

Lastly, wood patterns will often have metal parts. Thus the bearing faces for the shoulders of brasses when skewered on are usually made in metal, since in wood they would become broken in consequence of their fragility. The letters for name-plates also are cast in metal and fastened to a wood plate, and we shall find as we go along many cases in which the pattern-maker resorts to the use of metal as being preferable to that of wood.

Figs. 342 and 343 illustrate the casting of a common road wheel with strutted arms of wrought-iron cast in rim and

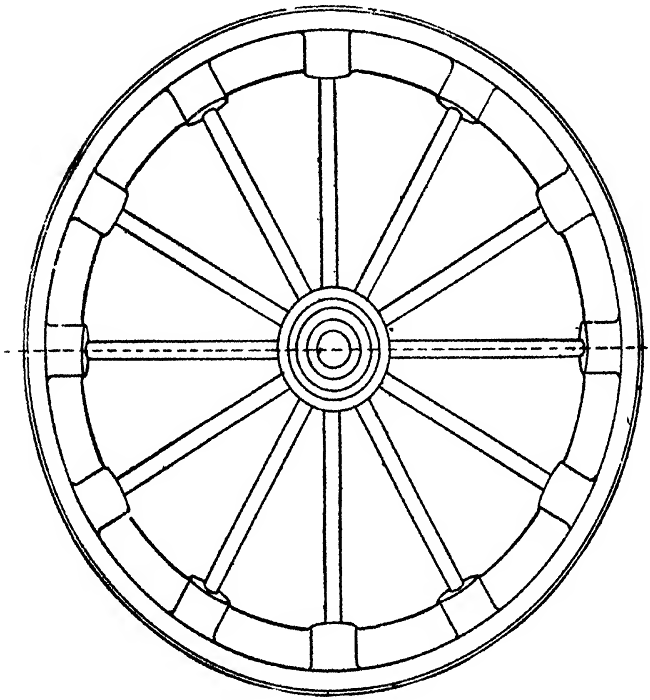


Fig. 342.

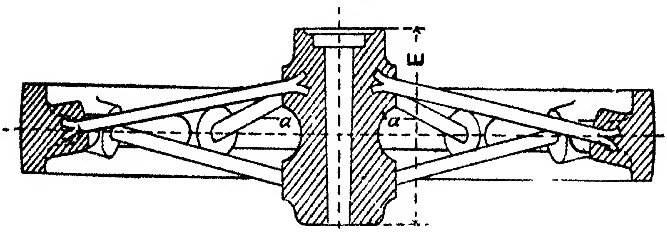


Fig. 343.

boss, as used for various kinds of portable engines, steam tractors, and agricultural machines. Such wheels are light,

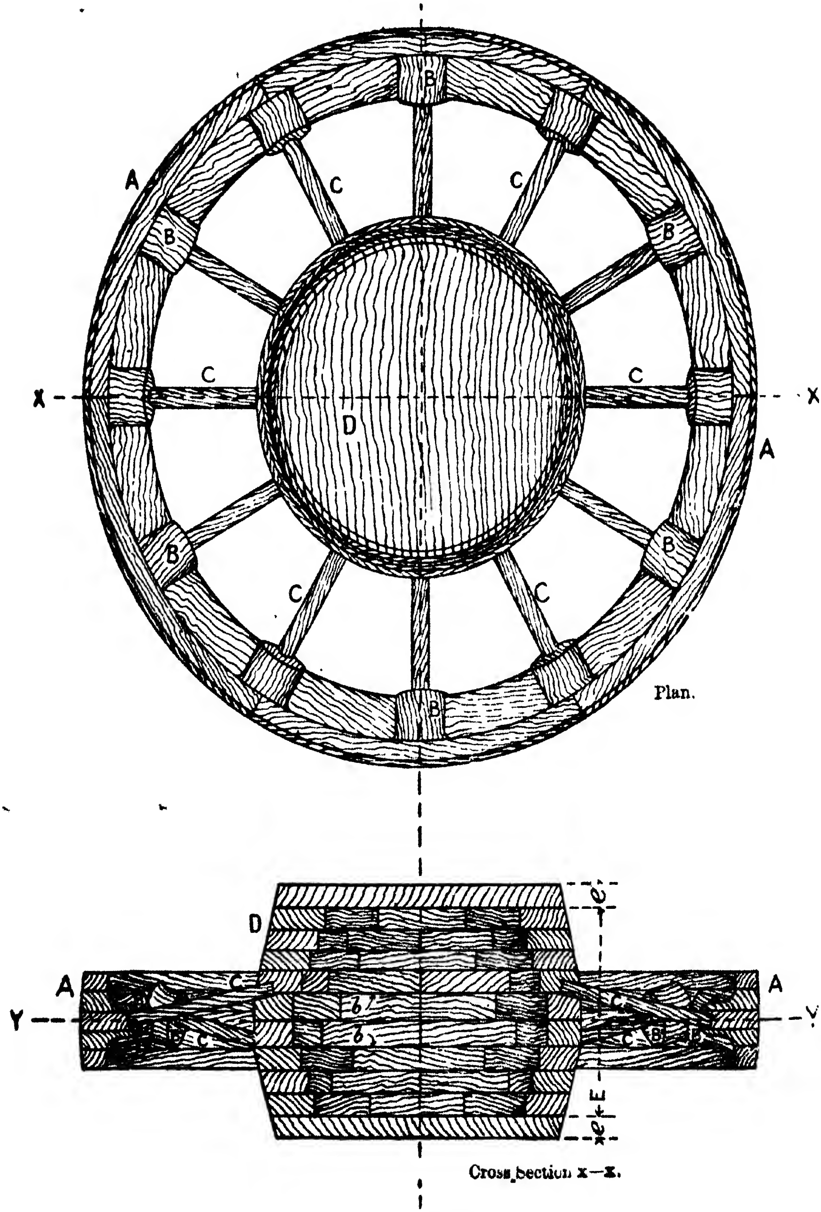
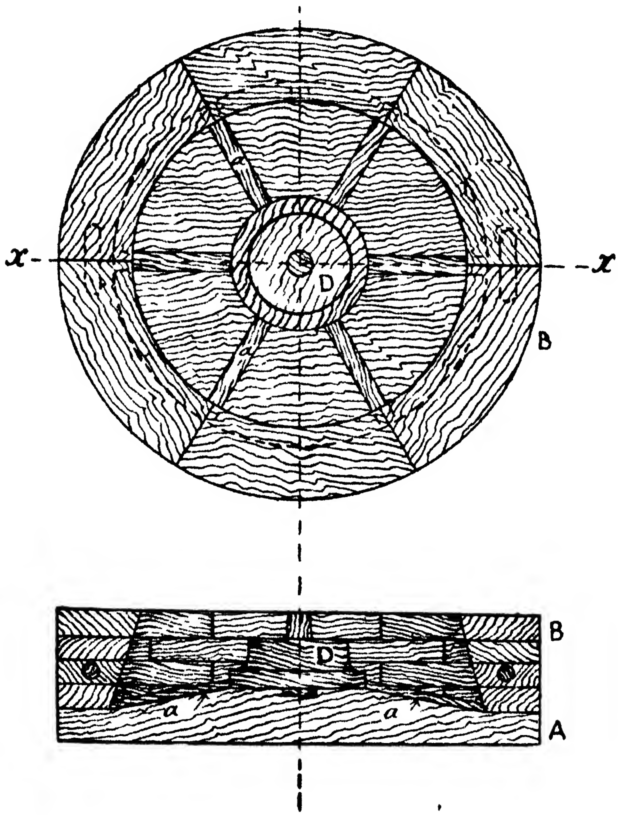


Fig. 244.

strong, and elastic, and although the work for a single wheel would be rather costly, they are not expensive when the pattern-work is once done, and the castings made in quantity for stock and standard types of engines. Wrought-iron arms are used also for large sheave-wheels and pulleys.



Section x—x.
Fig. 344.

Such a wheel can be made with, or without, a complete pattern, dependent on size and on number required off. We will take the case of a complete pattern.

Fig. 344 shows the pattern in plan, and cross-section. The rim A is built up with rows of segments, the number of rows depending on the depth of the rim—in this case

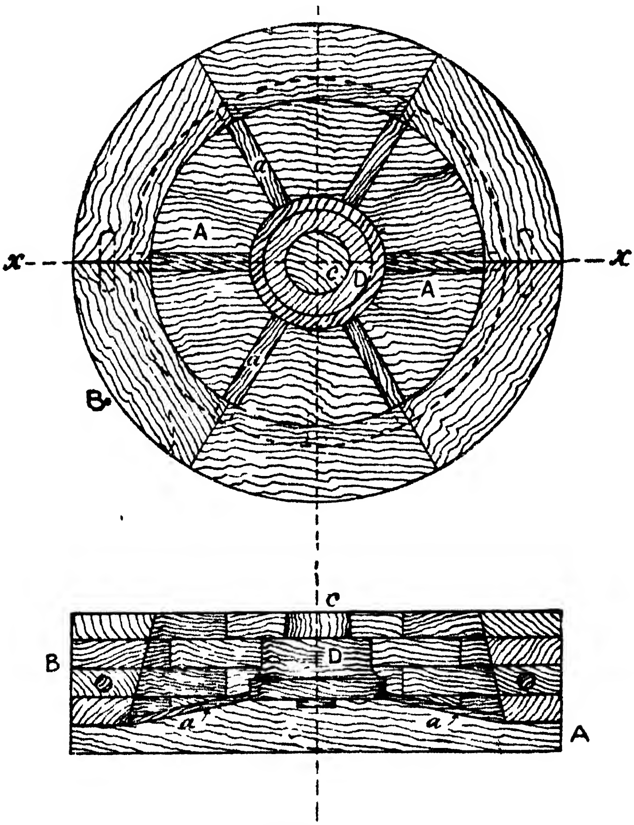
the rim is 3½ inches deep, and there are five courses of segments. The bosses, B, are fixed at the same bevel as the arms. They are turned entire, and recessed to fit over the internal rib at their proper angles, as shown in cross-section B in Fig. 344.

All this is simple enough; but the reason why I have selected this wheel as an example of pattern-work is because of the method of formation of the central boss and the strutting of the spokes or arms. If the boss were straight instead of being recessed, as in Fig. 343, *a a*, it would be practicable, though a little troublesome, to insert the actual pattern boss itself in the centre of the wheel pattern, connected therewith by means of the prints C in Fig. 344 for the spokes. Then sloping zigzag joints would be made by the moulder, reaching from arm to arm, and the boss would deliver half in the top and half in the bottom part of the mould. But the recessed shape of the boss at *a a* in Fig. 343 precludes the possibility of doing this; hence we form the whole of the boss with cores—a method both neat and accurate. The diameter of the cores is of little importance so long as there is sufficient length of prints available for the arms to lay in. Fig. 344 shows a suitable proportion of print D. Note that its top and bottom faces coincide not with the top and bottom faces of the boss, but with the faces of the prints for carrying the central core or the central chill, if the wheels are to be chilled. The distance E in Fig. 344 coincides with the distance E in Fig. 343, and the remaining thicknesses, *e e*, are print thicknesses. This is to facilitate the pouring of the boss. Observe, too, that there is ample taper given to the outside of the print, in order to prevent pulling down of the mould or crushing by the core. The print is built up in segments as shown. It is made in two portions, jointed along the plane Y Y, and then screwed together permanently.

The holes for the spoke prints, C, are bored at the required angle with a centre-bit in the bosses, B, around the rim. In the central boss, D, they are cut with a gouge or else bored with a bit. But in either case it is necessary to make temporary screwed joints in the planes *b b*—that is, the joints of the segments there will not be glued until after the arm prints are put into place. They are inserted and glued with the joints separated, and then the joints are glued, and the whole boss is a solid structure inclosing the arm prints at their proper

angles. All other details of construction, arrangement of grain, &c., are clearly shown by the shading.

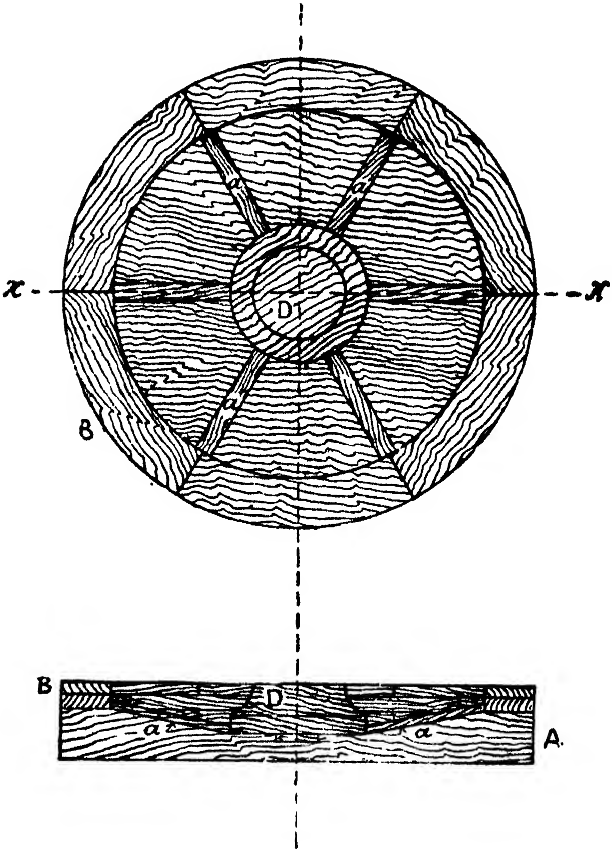
There are three core-boxes, shown in Figs. 345—347. Fig. 345 is for the bottom core, Fig. 346 for the top core, and Fig. 347 for the two middle cores, the last two being jointed



Section x—x.
Fig. 346.

face to face along the middle plane of the boss. It will be noted that in each case the core-box consists of a bottom board, A, dished to correspond with the amount of strutting given to the spokes, and carrying as much of the central boss as belongs to the core, and half-prints, *a*, for the arms. Also that the bottom board carries a ring, B, the internal diameter

and sectional shape of which correspond with the external diameter and sectional shape of the corresponding portion of the print into which the core has to fit. A comparison of Figs. 345—347 with Fig. 344, will render these correspondences



Section x—x.
Fig. 347.

clear. The rings in Figs. 345 and 346 are dowelled to the bottom board, and jointed across the diameter, in order to permit the boss to be drawn away from the cores without any risk of breaking down, which would happen if the rings were undivided. In Fig. 347, however, the rim is so shallow that it is fastened to the bottom board.

CHAPTER XIX.

SHEAVE-WHEELS.

Modified Provisions for the Reception of the Chain.—Patterns.—Mode of Jointing.—Built-up Patterns.—Templets.—Sheave-wheels with Cast Arms.—With Wrought-iron Arms.—Core-box for Rim-cores.—Central Boss.—Sheave-wheels made entirely with Cores.—Their Boxes.—Recessed Chain-wheels.—Rope-wheels.—Wave-wheels.—Projection of the "Wave."—Sprocket-wheels.—Wrought and Cast Fingers.

A SHEAVE-WHEEL is a wheel with a rim grooved or hollowed out for the reception of a chain or rope. We take the chain-wheels first in order.

In a plain sheave the chain lies in its groove in the direction shown in Fig. 348. But a chain when in motion is always apt to twist, and when, as in hoisting machinery, a heavy load is directly dependent from it, a sudden return to its normal position will be accompanied by a jerk, and, as a consequence, a considerable extra strain will be put upon it at once. Hence it is customary where the wheel is immediately over the load dependent from the chain, and not merely acting as a carrier

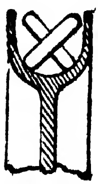


Fig. 348.

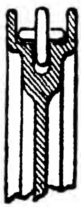


Fig. 349.

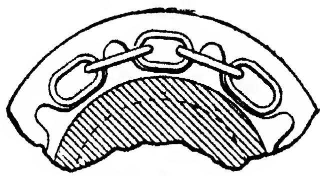


Fig. 350.

or support, to use, instead of a smooth sheave, one grooved out, so that the chain links may lie successively parallel with, and at right-angles to, its axis (Fig. 349). Further, in the differential pulley-block, and in all cases where the wheel has to draw the chain along, the friction of the simple groove would not be sufficient to overcome the resistance of the

load, and then the wheel is recessed at regular intervals to receive the alternating flat links (Fig. 350).

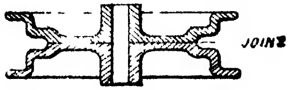


Fig. 351.

These wheels, if small, will have plated centres (Fig. 351); if moderately large, cast-iron arms with transverse ribs (Fig. 352); if very large, wrought-iron arms, which will be usually strutted (Fig. 353).

If a whole pattern—that is, one not cored out round the

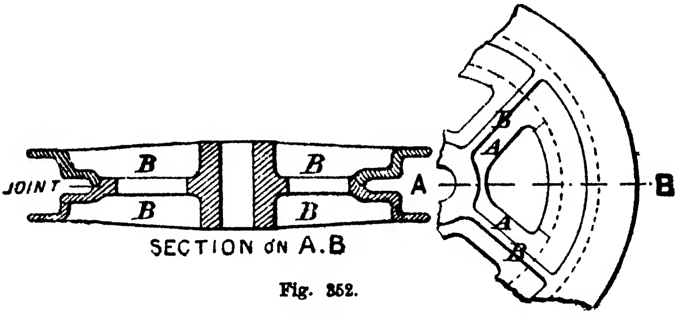


Fig. 352.

rim—be made for a sheave-wheel, it must be jointed in the centre, because the groove for the chain will have to be

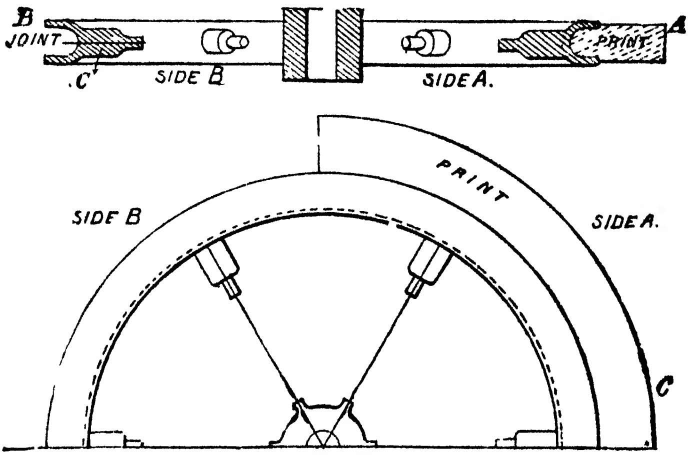


Fig. 353.

lifted away as a middle ring of sand. Whether it be a wheel with arms, or one solid plated, the joint may be made

either through the exact centre of the arms or of the plate (Fig. 351), or along their upper faces (Fig. 352), the ring alone in the upper portion being left loose. When, however, the rim is *cored* out, both rim and arms (or plate) and circular print are all made fast together (Fig. 353, side A).

Sheave-wheels are used generally as standard patterns, therefore it is well to take especial care in their construction. Glue them up in courses of segments, using thin stuff—say $\frac{1}{4}$-inch or $\frac{3}{8}$-inch—and good glue. Also peg each course with small pegs. Never mind about the pegs coming through here and there. If the wheel is plated, have at least two courses of segments in the plate, unless it be small—say less than a foot in diameter, in which case a piece of very dry solid stuff will do.

The wheel, when glued up, must be turned with templets made from the sectional drawing. Fig. 354 shows the half-pattern in section, and the method of cutting the templets for its inner and outer portions respectively. The centre hole for the studs of the bosses will serve for rechucking the pattern when one face has been turned. We prefer having a central stud hole for the reception of separate bosses, to making the bosses an integral part of the pattern, because we can then use the pulley for different sized shafts by simply making fresh bosses of the required diameters.

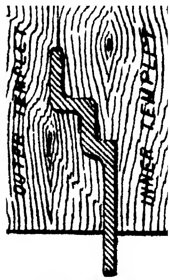


Fig 354.

But if instead of a wheel with a plated centre we have one with arms, we shall make those arms as for a spur-wheel, by locking them together and letting them into the rim (Fig. 352, A, A), there gluing and bradding them. Similarly bosses and cross-ribs (B, B, B, B), having a slight amount of taper, will be fastened to these flat arms. Hollows may be put in or omitted at discretion.

Next take a large pulley with wrought-iron arms (Fig. 353). In some cases it will be advisable to use a complete pattern on account of the number of castings demanded. The ring could then be made in the usual way by building up in two halves and jointing (Fig. 353, side marked B). The bosses and their prints (C) on the inside of the ring would be jointed also. This will answer very well where the wheel is of stout proportions. But if it were light in section, such a pattern would not bear foundry usage very long, and an iron

pattern would be advisable. But another method would be to build up a solid ring with a broad print (Fig. 353, side marked A), and to take out the groove with segmental cores — say ten or a dozen to the circle (Fig. 355, A). The advantage here would be that without making an iron pattern we should still have a rigid rim, not liable to become rammed out of truth—a matter of importance in a wheel of any kind. And further, although there is the additional expense involved in the making of the cores, we also save as a set-off against this the trouble of the middle-part box, since, instead of the joint on top and bottom, we want one joint only at the top face of the print.

The core-box will be made thus:—Two sides will be prepared (Fig. 355, B, B). Their outer edges (C, C) will be worked to the same radius as the outer edge of the print C, in Fig. 353. Their inner edges—straight—will extend about a couple

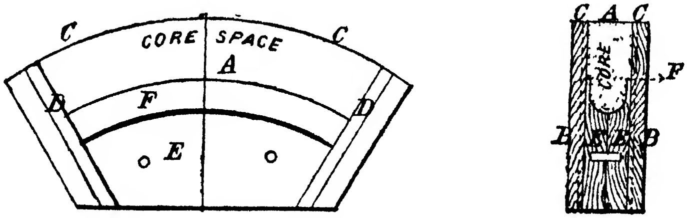


Fig 355.

of inches below the line which represents the bottom of the wheel groove. In these sides cut grooves (D, D) ¼ inch deep, radial from the centre of the wheel, and at a distance apart equal to the intended length of the segment of core; a sixth, tenth, or twelfth of the circle, as the case may be. Into these grooves drop distance pieces of the width necessary to keep the sides at their proper distance apart—that is, equal to the thickness of the print. Then fit a couple of blocks (E, E) between these sides and ends, parted longitudinally down the centre of the box and dowelled. Work their edges (F) to the same radius as the rim of the wheel, then mark on their ends the rim section. Cut out the groove thus marked with templet very truly, so that when the cores are made and laid end to end they shall correspond neatly, and not show a lapped joint in the casting. When worked, replace the pieces in position, and screw them one to each side of the box. It only remains now to put on the bosses for the arms, and to make

the central boss with its prints precisely as in the case of a flywheel with wrought-iron arms (Chap. XI., p. 157).

When the arms are strutted to give rigidity to the wheel, the bosses on the rim have to be bevelled alternately in opposite directions, and the prints on the central boss bevelled in like manner. These latter, too, in a strutted wheel should be *pocket* prints, and not round ones; for round prints would necessitate two joints in the body of the boss, coinciding with the centres of the prints, while with pocket prints the joint on the top face of the boss is alone required.

There is yet a common way of making a large sheave-wheel without a pattern at all. A glance at the sketch (Fig. 356), will indicate the method to which I allude. The light portion is the wheel rim in section—the dotted parts indicate two cores, one outer (A), one inner (B), forming outside and inside of rim respectively. It is seen that these cores are jointed at B, B. Of course the joint must be a curved one, both cores being worked to the same radius. The outer edges of the cores (C, C) need not be curved at all, because they form no part of the wheel. Give sufficient sand there, say two or three inches in the narrowest part, and some lesser amount, say 1 inch to 1½ inch, at the sides.

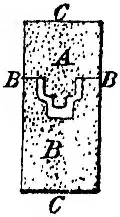


Fig. 356.

To make these boxes:—First frame sides and ends together for each respectively. Their ends must converge to the wheel centre, and must either cut through the centre of

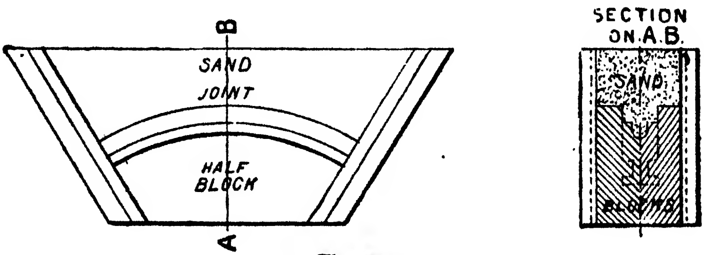


Fig. 357.

an arm boss or midway between two bosses. Thus, if the wheel have eight arms, there must be either eight or sixteen cores. Assuming there are eight cores, we have a half-boss at each end of the inside box. The boxes must be equal to each other in width, which will include the width of the rim and of the two sand joints (B, B, Fig. 356). Then blocks will

be fitted between these boxes, as in the last example; those forming the wheel *groove* will be worked out by templet to the shape indicated in Fig. 357, and those forming the inside portion of the rim will be worked like Fig. 358.* It is not necessary to fasten either of these blocks in place, for if their flat bottom edges are planed while in position level with the bottom edges of their boxes, they cannot shift when being rammed on a level core-bench or bottom board. The half-boss fastened on each end of the inner box, together with its arm print reaching to the termination of the sand (Fig. 358),

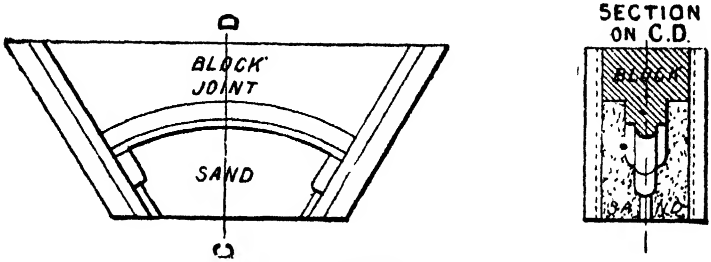


Fig. 358.

will complete the pattern-maker's part of the business. The moulder simply guided by a line struck on a level sand bed, lays a ring of inner cores in place, brings the outer cores to abut against these by the circular joint, thrusts the wrought-iron arms through their prints into the bosses, rams sand around the outside and the inside of the cores, and then casts the ring. When nearly cool the boss is cast around the opposite ends of the arms, as in the flywheel alluded to in Chapter XI., p. 157.

A sheave-wheel recessed for alternate links of a chain can be made by pattern or core-box. It requires almost as much care in pitching out as a spur-wheel, because if there is a slight initial error in the pitch, that error increases with each successive link. Thus, when we commence to lay the chain in, suppose we find the recesses are $\frac{1}{16}$ inch too far apart, the error will not remain at $\frac{1}{16}$ inch all the way round the ring, but will be $\frac{1}{8}$ inch in the third recess, $\frac{3}{16}$ inch in the fourth, $\frac{1}{4}$ inch in the fifth, and so on, so that by the time we had got half-way round a large wheel no reasonable amount of clear-

* Fig. 358 is drawn to show the position of the core relatively to Fig 357, the box, of course, being turned the other way up for ramming

ance between the links and their recesses would prevent the chain from riding out of place. In pattern wheels we can always insure accuracy by roughing out the recesses on a slightly larger diameter than we deem necessary; and then, trying the chain in, gradually reduce the wheel until it fits neatly all round. But when a wheel is made with cores we have not this chance, and then we must take especial care in getting the exact pitch of the links first of all, and in transferring that pitch to the drawing from which the core-box is to be made. Hence we must measure off the total length of a definite number of links, and divide that total length by the number of links measured; this average will be the pitch of the chain, which we forthwith transfer to our drawing-board. Working thus we shall not find our wheel at fault after it is cast. Some clearance is allowed sideways and endways for the links, say $\frac{1}{8}$ inch all round, and the recesses are worked out of the solid with gouge and chisel, in pattern and core-box alike.

In all other respects the directions we have given for the making of plain sheave-wheels will apply to these as well.

A common rope-wheel is similar to a plain sheave-wheel, with the exception that its inner sides are inclined at a somewhat acute angle in order to bite the rope in the bottom of the groove. This object is sometimes also assisted by little semi-circular bits, or nibs, pitched at regular intervals, and standing a little above the groove. Be the rope-wheels large or small, the same methods of making the patterns will be adopted as in the previous examples.

But there is a modification of this form which is sometimes used, and which is somewhat puzzling at first sight—I mean the wave-wheel form. It is a rope-wheel, in which the rim, instead of continuing in one circular plane, as in ordinary wheels, is bent or *waved* in serpentine fashion, the object being, of course, to increase the friction of the rope and thus prevent it slipping.

This is a device which is seldom adopted in small wheels, and therefore it is so seldom necessary that a complete pattern should be made thus that we shall only consider it as applying to a wheel made entirely with cores. The remarks we previously made as to the method of procedure to be adopted in the preparation of the core-boxes will be applicable here until we arrive at the working out of the internal blocks. Then our difficulty will be to insure that the metal in the rim shall be of uniform thickness throughout. If we go working away

at the curves at random, trusting only to the eye for accurate results, we shall probably find a variation of $\frac{1}{8}$ or $\frac{1}{4}$ inch in the thicknesses of different portions of the castings.

So we work in the following way:—Draw in elevation a

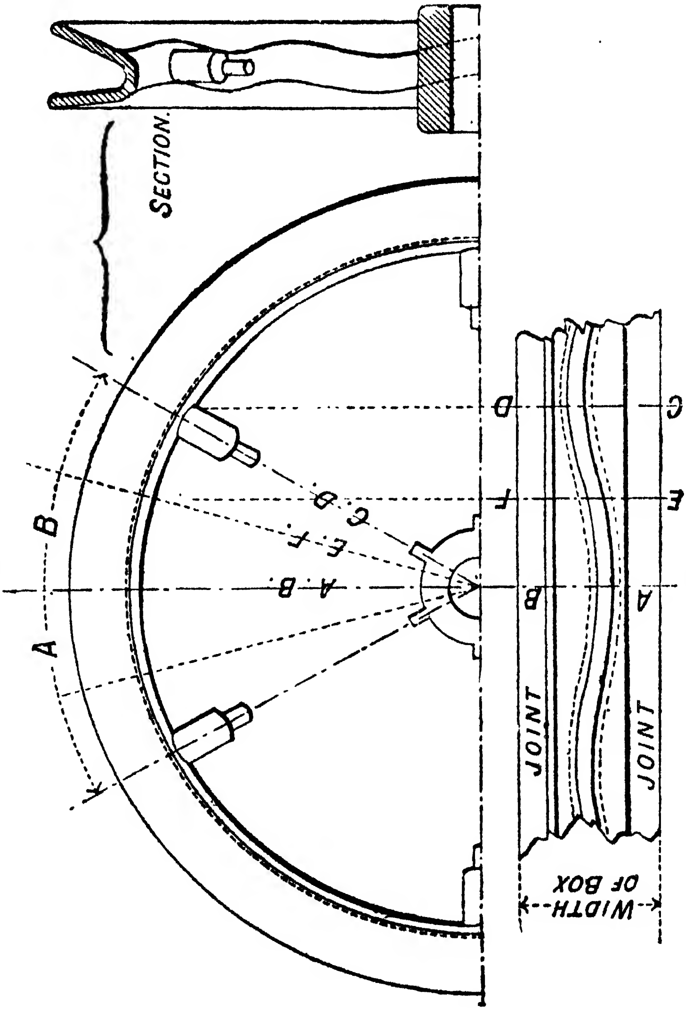


Fig. 359,

Fig. 360.

segment of the wheel, equal in length to the intended length of the cores (Fig 359, A, B). Draw also lines on this view converging to the wheel centre from the pitch distance of the

wave, viz at these points where it attains its greatest deviation from the plane of the wheel, A B, C D. Draw a portion of the rim with the intended width of the core-box besides in plan (Fig 360), and carry the lines representing the pitch across it. At these points draw sections of the rim in its extreme positions *relative to the sides of the boxes* (Fig 361). Between these extreme deviations of the wave draw other lines at

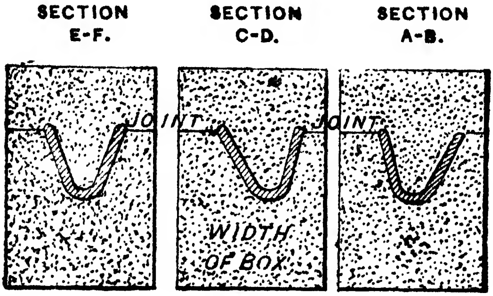


Fig. 361.

pleasure (not shown on engraving), projecting these to the plan, and drawing corresponding sections also in relation to the sides of the core-boxes. Then making templets to the inside and the outside of the rim, all we have to do is to work narrow portions of the rim at the distances from the edge indicated in the sections, and to shape the intermediate portions with gouge and chisel as regularly as possible. If this is done carefully there will be no appreciable difference in the thickness of different portions of the wheel rim when cast.

The last form of chain-wheel we shall describe is that known as the *sprocket* wheel (Fig. 362). It is a form which is in very general use for the transference of motive power by means of a flat link or "pitch chain." Like the chain-wheels, these require to be pitched out very carefully, else the pitch-chain would ride on the projections, or "sprockets," instead of dropping over them.

These wheels are made in two forms, the first like the Fig. 362, where the sprockets are made of wrought-iron and cast in the wheel body; the second like Fig. 363, in which the sprockets are a portion of the casting. In the former case they are dropped into prints, whose edges are their exact counterparts; in the latter, the pattern and casting are precisely similar.

In these castings the links must fit the places prepared for their reception so nicely that it is sometimes necessary in a large wheel to throw away the first cast and make a slight alteration in the pattern, a variation in the anticipated amount of contraction being sufficient to cause $\frac{1}{8}$ inch or $\frac{1}{4}$ inch of error in the semicircumference. The wheel might be saved in such

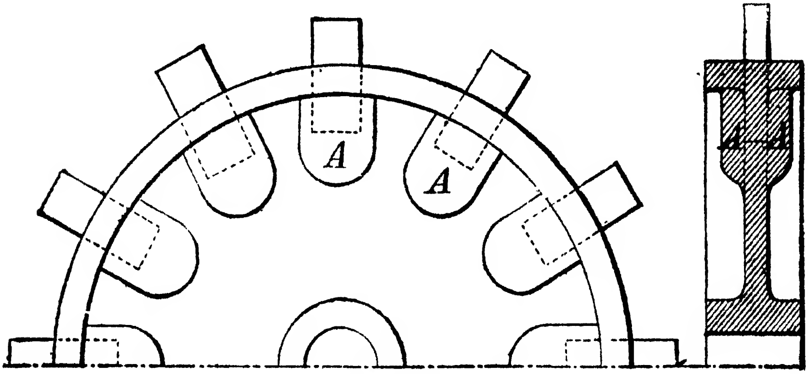


Fig. 362.

a case by filing a lot of clearance in the sprockets; but such a practice is not to be commended. The accuracy of a small casting can be depended on.

After what has been said about the building up of wheels, special remark is scarcely necessary in reference to these last-named. Note, however, that a built-up plate made in two or three thicknesses or segments is better than a single solid

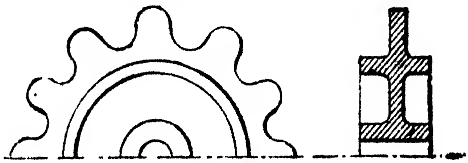


Fig 363.

piece of stuff in which the sprockets are cut out, because short grain and shrinkage are both avoided thereby. On this plate the two portions of the rim are built with segments as usual.

The prints for wrought-iron sprockets should be pocket prints, to be stopped over after the sprockets are placed in the mould.

In Fig. 362, A A, are the boss thicknesses around the wrought-iron sprockets.

CHAPTER XX.

CHAIN BARRELS.

Various Kinds of Barrels.—Plain and Spiral.—Barrels made from Loam Patterns.—Mode of Striking-up.—Barrels made from Loam Moulds. —Striking-up.—Right and Left-handed Spirals.

MANY barrels are made quite plain around their circumference, and then the chain can only lie at an angle (Fig. 364). The disadvantage with these is that the links are apt to override

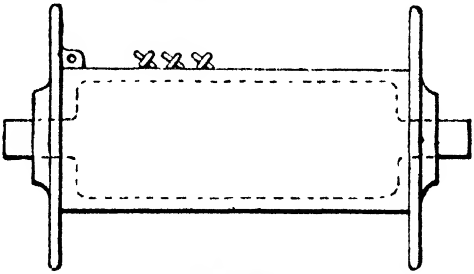


Fig. 364.

one another, with the result of straining the chain when they are jerked into the normal position by a load pulling at them. Barrels grooved spirally to take the links in flat and vertical positions alternately are made with the purpose of obviating this dangerous liability (Fig. 365). Barrels also not grooved with deep link recesses, but simply hollowed out spirally to take the links in angular position, without the danger of overriding, are also made (Fig. 366).

The pattern of the plain barrel presents no difficulty. The remarks made in reference to the building up of plain cylinders and columns will apply to these barrels. If small, they are made of solid stuff, jointed and dowelled of course; if large, they are "lagged up." The flanges and their bosses are turned separately and screwed on the ends, and

the prints for the hole for the barrel-shaft are fastened outside of these again. The spiral, whether it be a groove or a hollow, is marked out by points of equal division in the manner

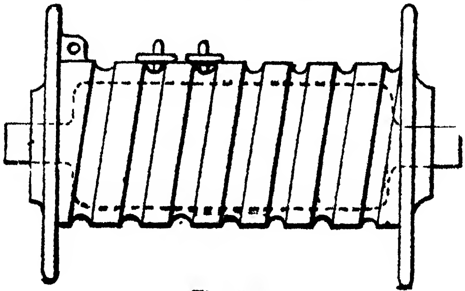


Fig. 365.

adopted when making pattern screws. Thus if the pitch of the screw on our barrel were 3 inches, divide that into, say, a dozen equal parts, and divide the circumference into precisely the same number. Through the successive in-

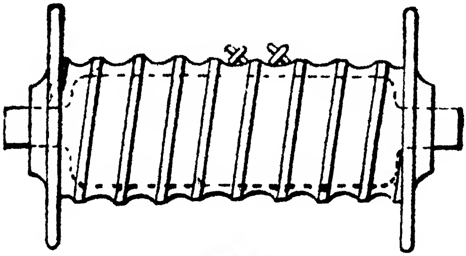


Fig 366

tersections carry the thread. Mark another line parallel with the first for the width of the groove, and work with gouge and chisel. The central core is struck by a loam-board.

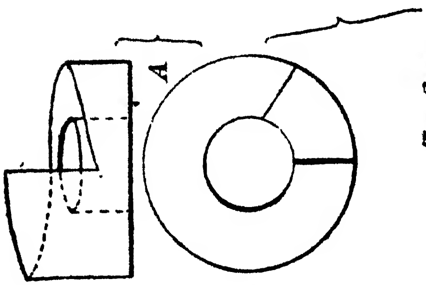
But the cost of patterns of this kind, except where the same type of crane is being constantly repeated, bears too great a proportion to the cost of the castings. In such cases a plain barrel already in stock, of the diameter of the bottom of the groove, is sometimes utilised by having lead strips cast to the section (Fig. 367), and bent round and fastened with screws. Yet this is a clumsy method, and not to be recommended.

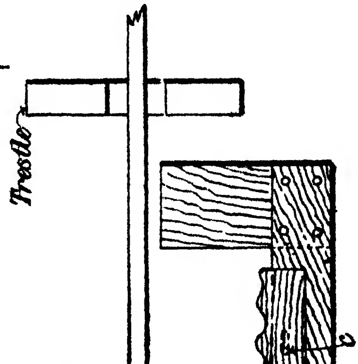
Fig. 367.

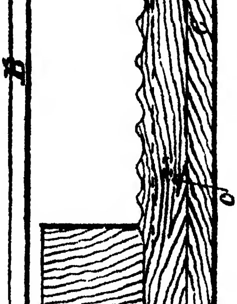
A better way, if the barrel does not exceed 20 inches or 24 inches in diameter, is to make a good *loam pattern*, which, if well made, and protected with a coat of tar, will

stand several mouldings before it becomes rotten. If the barrel exceeds these diameters, a *loam mould* is our only choice.

To get the spiral groove, a good deal of rigging up is required, after which the process is as simple as possible. Let us take the loam *pattern* first in order.







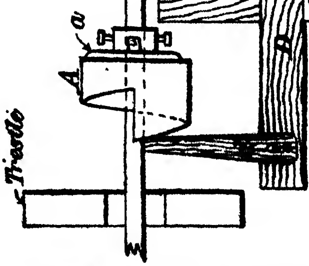


Fig. 368.

We require a loam-board grooved along its edge like the barrel whose pattern it is intended to strike, but in the reverse way. Evidently also some arrangement by which the board shall travel a distance equal to the pitch of the screw during one revolution of the core-bar; in fact, an apparatus as regular in its motion as a screw-cutting lathe. But it would be preposterous to think of fitting up change-wheels to a core-bar, so we devise some simpler but equally (for our purpose) effective method. Fig. 368 shows the arrangement.

A is a block of wood turned to any size, say, a foot in diameter, and bored to fit loosely over the end of the core-bar, B. One face of this is cut to form the face of a screw of exactly the same pitch as the spiral on the barrel. Two pieces of paper, equal in length to inner and outer circumferences respectively, and cut to the pitch—that is, tapering from 3 inches to nothing on their lengths—

and glued round the inner and outer diameters, give by their slant edges the lines by which the face of the block is to be worked. On the back of the screw-block a face-plate of iron, *a*, is attached, and by means of the set screws in the boss the screw can be adjusted truly on the bar.

The loam-board consists of two portions—the lower, C, which strikes a loam body ¼ inch or thereabouts less in diameter than the base of the grooves, and the ends, the bosses, and the prints beside, not shown. Over this comes the grooved board, D, which slides upon the bottom one by means of two hardwood pins, *e*, *e*, working in slots, which slots permit of its motion in a rectilinear direction over a space equal in length to the pitch of the screw.

Now all is clear enough. After the loam body is struck up by the bottom board, the latter is of no further service save as

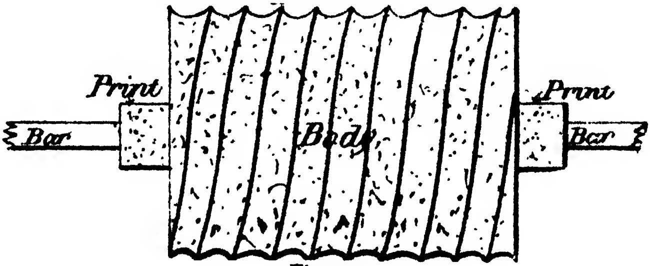


Fig. 369.

a base for the spiral board. It is accordingly drawn back to clear the points of the screw, and the top board dropped into place by means of the pins, in a position corresponding with the commencement of the screw-thread. A boy then turns the handle of the core-bar, and while the core-maker daubs on the loam, another boy steadies the board whilst it is being pulled along by the screw A through the medium of the tongue piece *d*, working against the screw face. Immediately that it gets close to the extreme of the screw pitch the boy at the handle turns more slowly, until the shoulder of the screw is reached, when boy number two slides the board sharply back to the commencement of the thread once more. After this process has been repeated, say, eighteen or twenty times, the loam pattern screw is neatly finished, and is ready to go into the stove to be dried. The loam pattern, when struck up, has at this stage the appearance of Fig. 369. The flanges and facing bosses are made of wood, and bored to fit the loam prints.

Very large drums are so seldom in demand, that usually one casting alone is wanted at a time. Then, if the diameter will permit of a man standing upright within it to work, we make a loam mould. This requires a special rig-up, the same in principle, but differing in detail, from that last described. The same guiding-screw will be used, but it will be laid in

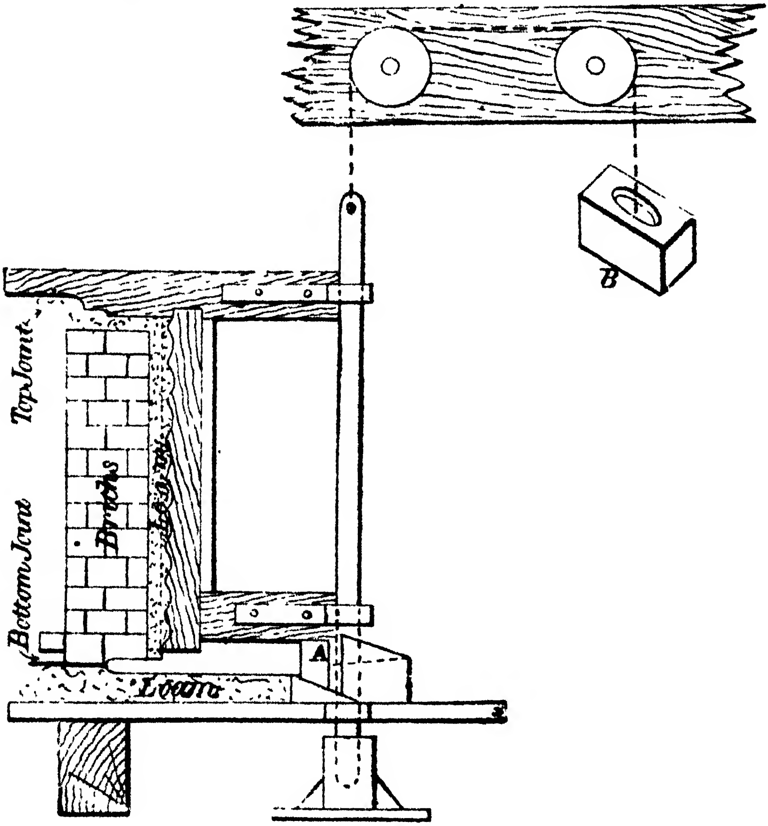


Fig. 370.

the bottom of the mould in a recess specially struck for its reception by the bottom loam-board. The striking-board also, instead of being cut reverse to the screw grooves, as in the last example, will be cut like them; because, in this case, it has to strike the actual mould and not the pattern itself. The apparatus for striking will still be made in two, but will differ from the last in these particulars. First, there will be the

under plain board for striking the loam body, not as in the last, ¼ inch smaller than the base of the grooves, but the conditions being reversed, ¼ inch larger than their tips. Then the second board, its edge cut to the shape and pitch, will not work in slots, but will be screwed to the first-mentioned one, and the necessary vertical movement will be accomplished by another device. Fig. 370 represents the apparatus rigged-up ready for striking the spiral. The top joint will have been struck before the screwing-tackle is put in.

A is a block of wood carrying a small iron roller, enlarged at Fig. 371, which runs on the face of the guiding-screw, the block being fastened firmly to the bottom bar of the striking-board with wood screws. B is a counterpoise which, by taking the weight of the board and striking-bar off the roller, allows the whole affair to run with very little friction, and leaves the moulder free to give his attention to the loam without much expenditure of muscular effort. When the board drops from the top to the bottom of the guiding-screw at the end of each revolution, a groove will necessarily be cut in the loam equal in width to the thickness of the board; this the moulder will fill up when wet, and dress off afterwards when dried. With this

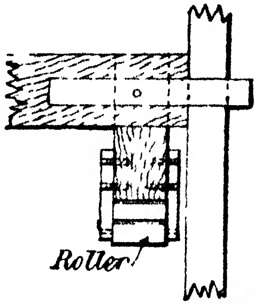


Fig. 371.

Section thro' middle part of Mould

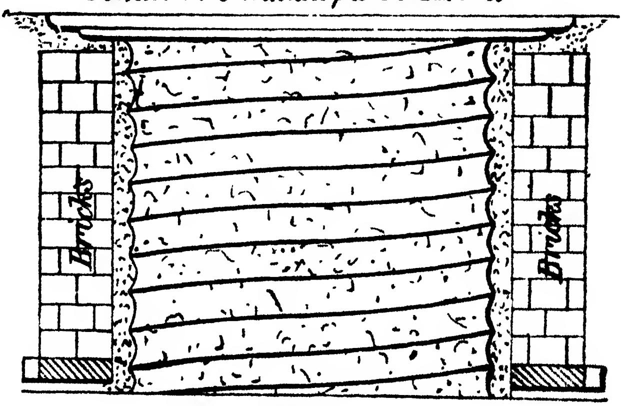


Fig. 372.

exception, the action is quite automatic; the moulder has

merely to move the board around, and see that the loam he throws against its face is of the proper consistence. Fig. 372 shows half a section of the middle part of mould. In cranes of heavy construction it is common to have two chains winding at once, one from each end of the barrel. This means a double spiral, right and left-handed (Fig. 373), and, of course, two guiding-screws, one cut to a right-hand, the other in a left-hand direction. The grooved board also will be only half the length of the other, and will strike the two screws distinct.

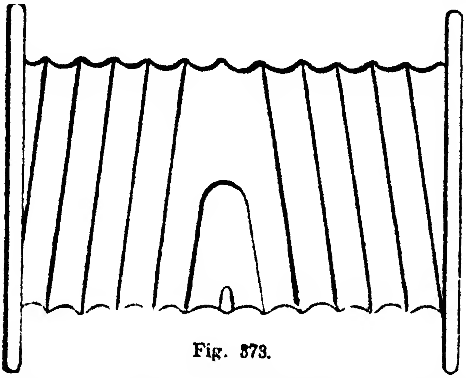


Fig. 373.

Thus, say the screw commencing at the centre of the barrel and running upwards is right-handed, while the other running downwards is left-handed. The grooved board will be screwed on first for the top screw, and the right-hand guiding-screw put in the bottom. When it is struck, the grooved board will be removed to the bottom, and the left-hand guiding-screw put in. The bottom screw is struck last to prevent its receiving damage from the tumbling down of loam from above.

The making of the lugs, or recesses, as the case may be, for the attachment of the chain or chains is too simple a matter to call for comment, and the making of flanges and boards, top and bottom joints, has already been described.

The method adopted to procure a spiral groove has been dealt with at some length, affording as it does useful information, but it must be remembered that in quantity production it might prove more profitable to cast the barrel plain, and transfer to the machine shop, where the groove could be cut. For cutting spirals on small work gear-driven spiral heads are available, these being also provided with indexing mechanism.

CHAPTER XXI.

MACHINE TOOLS.

Lathe Beds.—Advantages of Coring Beds.—**Boxing** up.—**Attachments** —**Core-boxes.**—Saddle for Slide-rest.—Transverse Slide.—**Standard.** — **Headstocks.** — Planing Machine Bed. — Loose Strips. — **Cored** Portions. — Taper. — Standard of Machine. — Chaplet **Blocks** for Cores.—Travelling Table.—Open Joints.

THERE are two ways of making lathe beds: one is to construct the pattern like the casting, leaving certain parts loose, and giving due taper both to external and internal portions; the other is to box up a pattern, and to core out the internal portions. Of these two methods I am going to describe the latter, because with a cored-out pattern there is less chance of an untrue casting being produced, such a pattern being less liable to become rammed winding, or otherwise out of truth in the sand. If I were going to make a small bed such as this is for myself, knowing the moulder who would mould it, and that I could check it with straightedge and strips in the sand, I would not bother with cores; but if cast in a strange foundry, perhaps by men unaccustomed to this class of work, I would not run the risk of getting a crooked bed by constructing a pattern of so slight proportions. To such as wish, however, to mould in greensand simply, the view of Fig. 374 is self-explanatory. A pattern made thus (one only of two or three methods) will be made correctly for moulding, remembering of course that the top of the bed is the bottom in the mould.

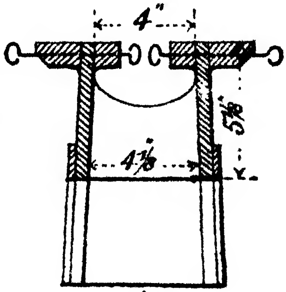
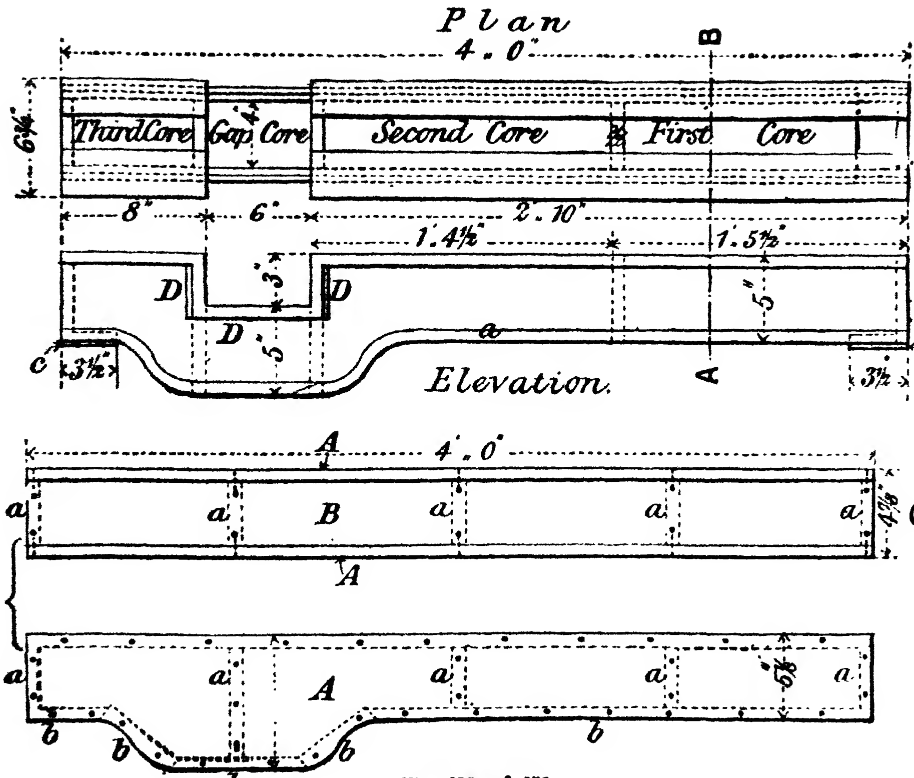


Fig. 374.

Fig. 375 shows a fairly proportioned bed, dimensioned for the sake of clearness of illustration. It might perhaps be lengthened six or twelve inches with advantage, dependent upon the class of work for which it is to be adopted.



Figs. 375 and 376.

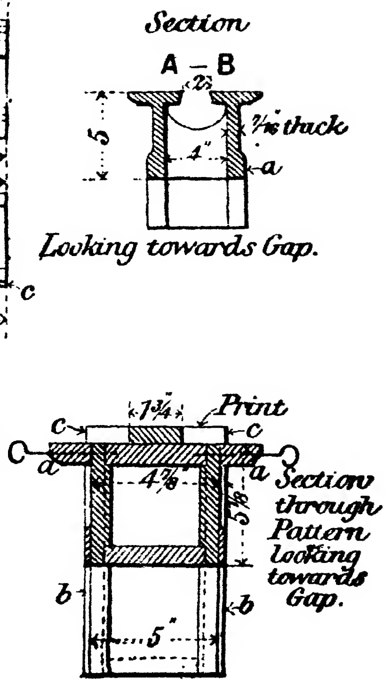


Fig. 377.

"Box up" the main body of the pattern (Fig. 376). Procure some inch board, out of which cut two sides (Fig. 376, A, A, A) slightly larger than the outline of the bed. Rebate them $\frac{1}{8}$ inch deep to the width of an inch all round, and also across where the ribs or stays, *a, a, a, a, a,* are to come. Then prepare one piece for the top (B) 4 feet $\frac{1}{8}$ inch long by about $3\frac{3}{8}$ inches wide. We say "about," because the stuff in the sides may be full or bare in thickness, and we want the bed to measure 5 inches over the sides when roughly boxed up, the finished width being $4\frac{7}{8}$ inches. Prepare pieces likewise for the bottom, *b, b, b, b, b,* of the same width as the last, also the cross ribs, *a, a, a, a, a,* of the same width too. Nail or screw all together. Plane up the sides to $4\frac{7}{8}$ inches wide at the bottom (bottom from the moulder's point of view, really the top face of the lathe bed) by 5 inches bare at the top. Plane over the face straight and square with the vertical centre of the bed—*i.e.* so that the taper in the sides is equal relatively to the top; shape the blocks that form the swell round the gap, and plane $\frac{1}{16}$th taper at the ends of the bed.

The main body is now ready to receive its equipments. Make a print 4 feet by $1\frac{3}{4}$ inches by $\frac{1}{2}$ inch and nail it upon the centre of the face (Fig. 377). (In reference to the apparent discrepancy between the width of the print here given and the width of the groove in Fig. 375, as also to other instances of the same kind, as $5\frac{1}{8}$ inches depth of bed in Fig. 377 against 5 inches in Fig. 375, let me remark that these are the usual "planing" allowances.) Extend the width of this print *just over the intended gap* to $4\frac{7}{8}$ inches (Fig. 378, Fig. 377, *c, c*),

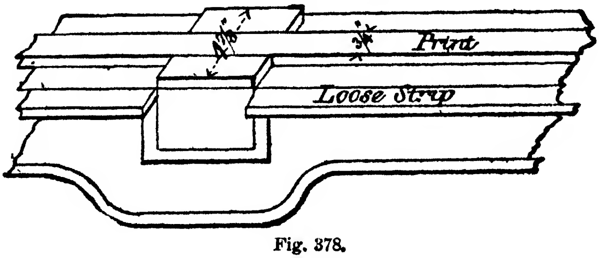
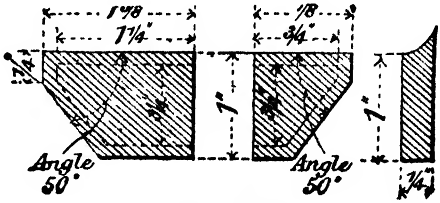


Fig. 378.

the reason of which provision we shall see by-and-by. Prepare the outer V-shaped strips to the sections (Figs. 379, 380), and wire on in place (Fig. 377, *a, a*). The outer lines in Figs. 379, 380 are the *pattern* lines, the inner ones represent the *planed* sizes. Make the fillet to section (Fig. 381), planing

the straight portions, and cutting the curved parts round the gap with gouge and chisel, and nail or screw in place (Fig. 375, *a*, *a*; Fig. 377, *b*, *b*). The strips, D, D, D, round the gap must, however, be wired on. The two facings for the standards, 5½ inches by 3½ inches by ¼ inch (Fig. 375, *c*, *c*), complete the pattern.



Figs. 379, 380, 381.

For the first core (Fig. 375, plan), frame up a box 1 foot 5½ inches by 4 inches by 5⅝ inches (Fig. 382). This is long enough to include the first and second ribs, and deep enough to include the print. Plane two strips 1 foot 5½ inches by 1⅜ inch by 1⅛ inches, equalling respectively length of box, depth of inner strip and print, and width of inner strip with planing allowance, and screw them against the sides of this box flush with its top edge (Fig. 382, A, A). Prepare two cross-bars ½ inch thick to the shape and dimensions indicated in Fig. 383, which represents a section of the box, looking towards the end, and screw in place (Fig. 382, B, B). Prepare a piece 4 inches by 3 inches by ⅜ inch, and fasten at one end for the standard facing (Fig. 382, C).

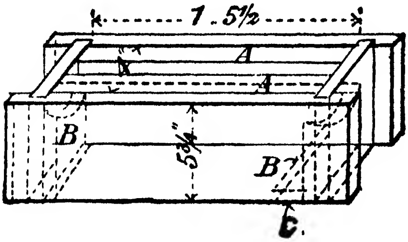


Fig. 382.

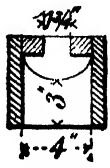


Fig. 383.

The next box is framed to 1 foot 4½ inches by 4 inches by 5⅝ inches, and one end is made to follow the outline of the pattern (Fig. 384). In the end next the gap, a cross-bar similar to the others, but 3 inches deeper, is fixed (B). The guide strips, A, A, for the poppet, as in the last box, will be required. The box for the third core (Fig. 385) will be 8 inches by 4 by 5⅝, having strips, A, A, cross-bars, B, B, and facing, C, for standard; or the second box may be utilised after its core is made by screwing a cross-bar in, 8 inches from the end next the gap, and putting in the necessary parts.

The gap box (Fig. 386) is framed to 6 inches by 4⅞ inches by 8⅝ inches. This, it will be seen, corresponds with the

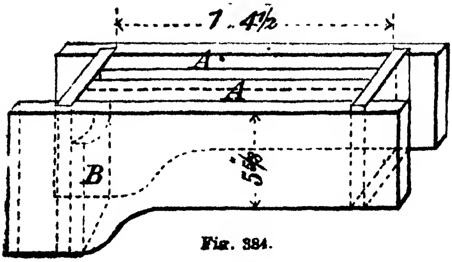


Fig. 384.

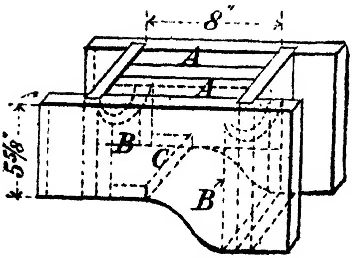


Fig 385.

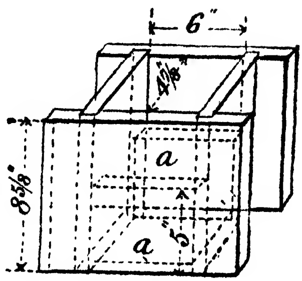


Fig. 386.

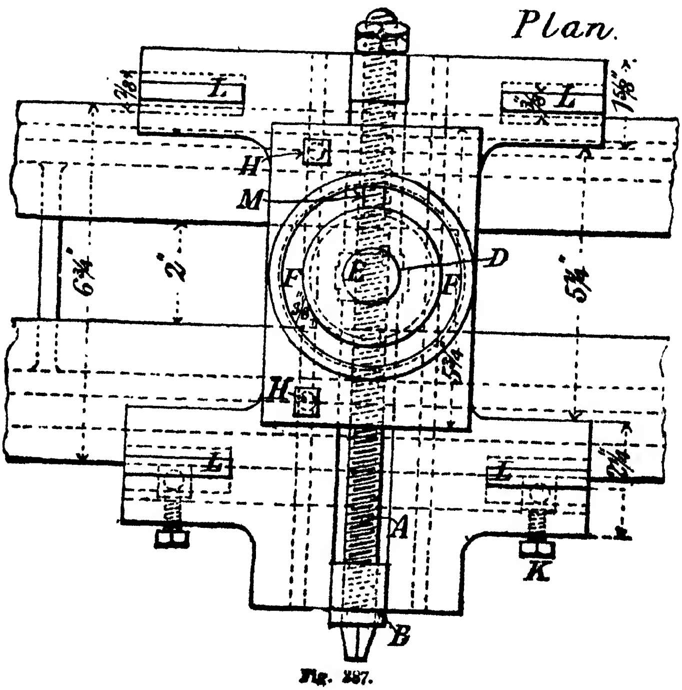
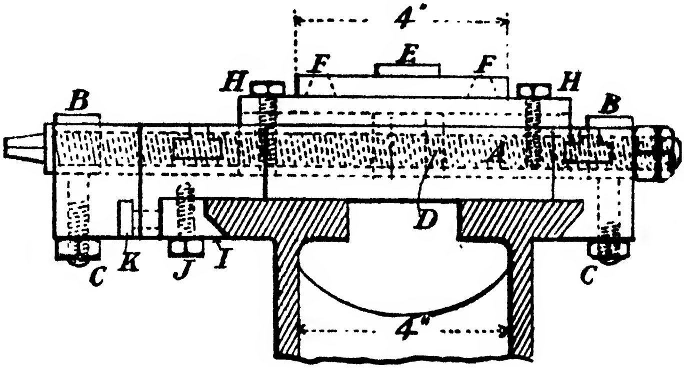


Fig. 387.

print in Fig. 378. Against the sides of box screw two blocks 6 inches by 5 inches by $\frac{7}{16}$ icnh (Fig. 386, *a*, *a*), to form the metal at the sides of the bed below the gap.

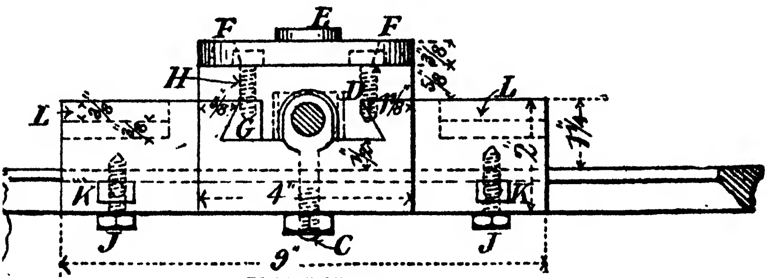
Fig. 387 shows the saddle and transverse slide suitable for the bed we have just described in plan, Fig. 388 gives a side



END VIEW.

Fig. 388.

view, Fig. 389 one in front. A is the screw ; B, B are the nuts attached to the saddle by the screws C, C ; D the nut held in



FRONT VIEW.

Fig. 389.

the transverse slide, through the medium of which the motion of the screw is communicated to the slide; E the stud for the longitudinal slide; F, F a turned bevelled groove to receive the tightening nuts for the upper slide; G loose strip for transverse slide, tightened up by screws H, H ; I is the loose strip for the saddle, fastened by screws J, J, and *set* by screws

K, K; L, L are slots for T-headed bolts, for convenience of holding work to be bored. The bosses for the rack pinion movement are omitted to avoid crowding.

Taking the pattern of the saddle first (Fig. 390), make the main plate 2 inches thick, to dimensions given, framing the

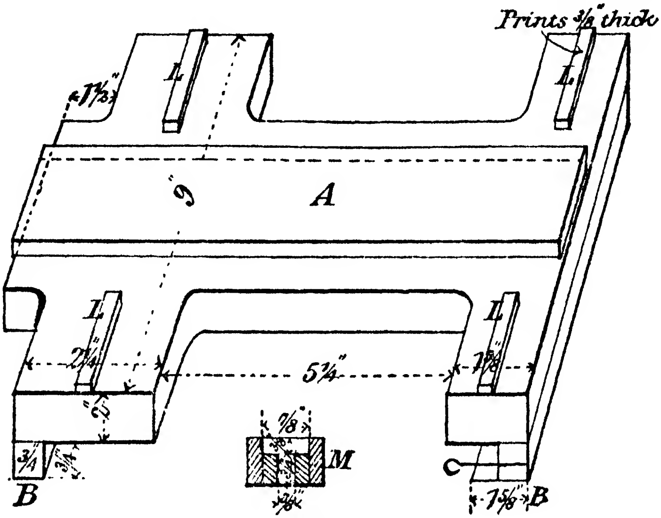


Fig. 390.

parts together either with half-lap joints or by mortises and tenons; nail on a print, A, ½ inch thick, to take out the recesses for the transverse slide; screw on the strips B, B which embrace the lathe-bed, wiring on the Vee, which is cast in a piece with the saddle. Fig. 391 shows a section of the core-box for A, looking towards one end. By means of the curve, *a*, on the end cross-bars of the box, the core is strickled to a corresponding shape

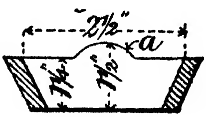


Fig. 391.

Fig. 392.

for the purpose of taking out the recess underneath the traversing screw. The prints, L, L, L, L, and their core-box, M, shown in section, Fig. 390, are for the T-headed slots, shown in the three views of the rest. Fig. 392 is a half-size section of the loose Vee strip, I, in Fig. 388, giving planing allowance

Fig. 393 shows the pattern of the transverse slide, top and bottom faces respectively, and Fig. 396 in end view. The plate A is $5\frac{3}{4}$ inches by 4 inches by $\frac{3}{4}$ inch (finished to $\frac{5}{8}$ inch). Upon this the circular face, with its print for the bolt recess, B, Fig. 394 in section, is fastened. Fig. 395 shows the core-box for this recess, in section and plan. A is a bottom board upon which a

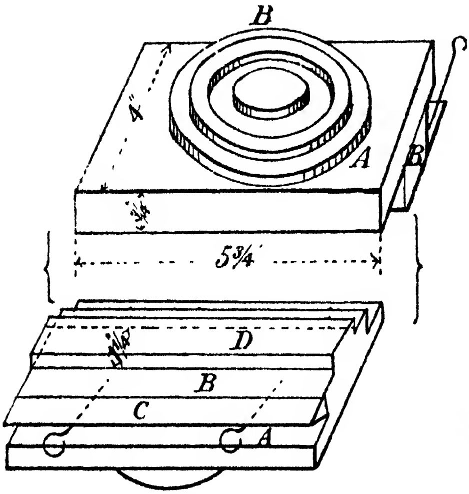


Fig. 393.

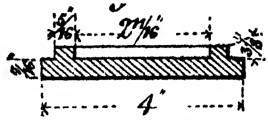


Fig. 394.

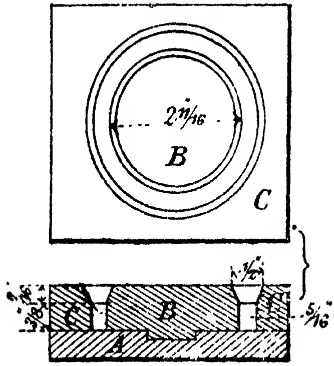


Fig. 395.

centre-piece, B, is studded, and a ring piece, C, dowelled; the unshaded portion being the core space. Note that the width of core is given as $\frac{5}{16}$ inch against $\frac{5}{8}$ inch width of groove on top of Fig. 387. This allows of the barest possible amount of skimming up in the lathe, the core being too small to permit of much turning allowance, neither is much necessary if the box be made truly.

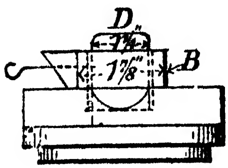


Fig. 396.

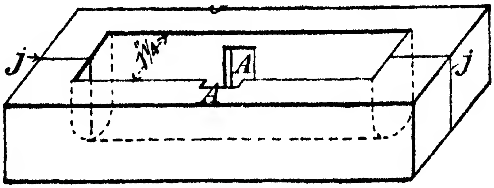


Fig. 397.

A slot will have to be cut in the casting, shown at M in Fig. 387, through which to thrust the tightening bolts into place.

For the under face of the traversing slide prepare a piece of stuff $5\frac{3}{4}$ inches by $1\frac{7}{8}$ inch by $\frac{3}{4}$ inch, and fasten on in the centre of the plate already prepared (Figs. 393, 396, B); on this wire the loose strip, C, and nail the print, D. Make core-box (Fig. 397) jointed longitudinally, *j*, *j*, and dowelled and recessed at sides, A, A, to receive the brass nut (Figs. 387, 388, D, and Fig. 398).

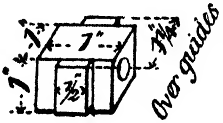


Fig. 398.

The standard (Fig. 399) is suitably designed for the bed which we have described. The frame will be made with

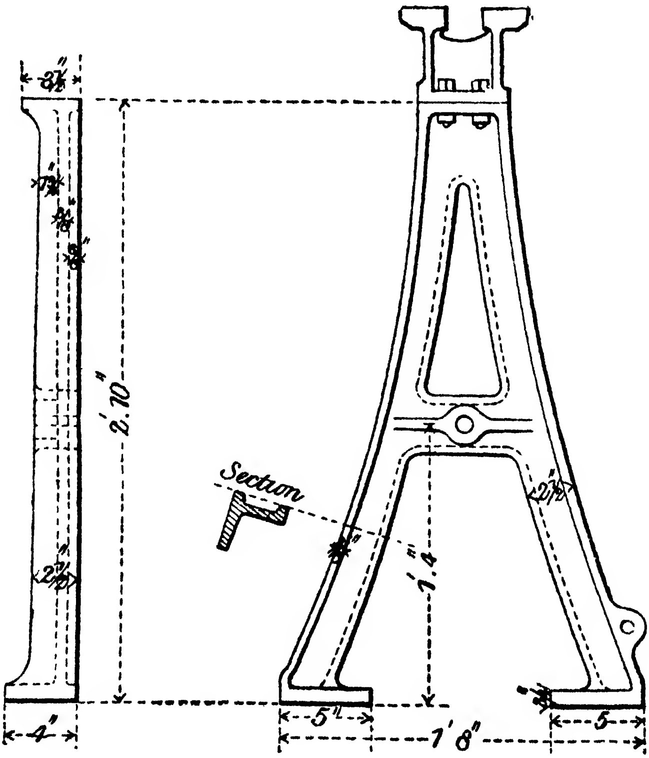


Fig. 399.

half-lap joints, and the ribs screwed upon it with $\frac{1}{16}$ inch of taper on their inner faces. The $\frac{3}{8}$ inch ribs on the outer

face simply relieve the otherwise heavy appearance of the casting.

Headstocks and poppets are jointed either longitudinally in their vertical plane, thus moulding upon their sides, or they are made to mould top side down, the barrel of the poppet being loose in that case, and the overhanging portions also of the headstock being left loose; or where the overhang is con-

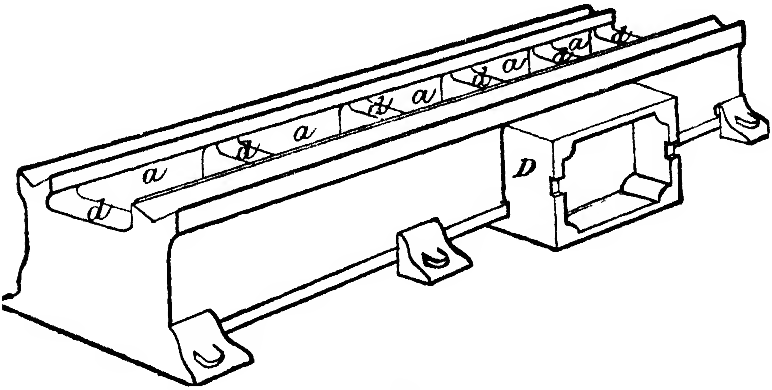
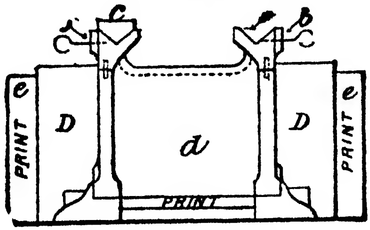


Fig. 400.

siderable, as in arms for back gear, the sides are taken away on drawbacks.

Taking the bed of a planing machine (Figs. 400, 401) we observe the V-shaped grooves for the sliding table, running its whole length, and projecting several inches within the sides. They are planed truly linear and smooth; hence they must mould downwards. Moulding thus, it is necessary that they should be left loose, and the best way of jointing is to dowel as shown (Fig. 401). After the main pattern is removed, and the middle sand cores (*a*, *a*, *a*, *a*, *a*) are lifted out, these strips could be drawn upwards but for one obstacle — the overlapping portions, *b*, *b*, projecting beyond the outer edges. These, therefore, should be wired loosely on the already dowelled pieces, to come in after their removal. Or, if the hollow on *b* is not



Section of Bed.

Fig. 401.

undercut, the V strips entire may be drawn in after the removal of the bed by a sidelong motion in the direction of the arrow—that is. of the outer V face. Sometimes, however,

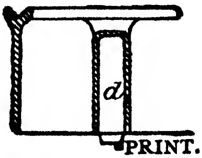


Fig. 402.

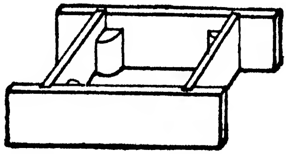


Fig. 403.

the V's are taken out with cores, in which case the print C (left-hand side) would prevent the removal sideways, and the outer piece must be left loose.

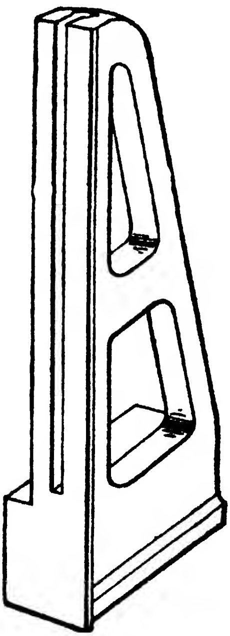


Fig 404.

The cross-bars, *d*, are cored out (Fig. 402) with the view of lightening them, and thin prints for that purpose are fastened on the back and lifted in the top. The outside faces of these cross-bars, together with the sides of the bed, should have at least ⅛ inch of taper, or more if the bed be large. The blocks, D, D, upon the sides (Figs. 400, 401) are for the attachment of the upright standards, and are cored out with prints, *e*, *e*, screwed against their sides. The bosses in the corners are for the purpose of receiving the bolts which retain the two parts together, and are placed in the core-box (Fig. 403) at a distance below its edge equal to the thickness of the prints, *e*, *e*. These blocks and the cross-bars are "boxed up" and attached to the sides with screws. The feet are worked out of solid stuff and screwed on permanently, as also is the fillet or moulding running round the bottom edge. The bosses for carrying the driving and quick-return shafts, &c. (not shown), must all be wired on loosely. Such a bed should have lifting straps down its sides.

It may be taken as a rule in ribbed or flanged castings that

plenty of taper should be given to those faces which are not working parts. Strength is not sacrificed—the average thickness being maintained—and the risk of the breaking up and damaging of the mould is vastly diminished. Also, *round* all parts that can be rounded—the edges of these cross-bars for instance—a rounding edge having a more graceful appearance than one quite angular.

The standard (Fig. 404) is either "boxed up" or made of solid bars mortised together. It moulds upon its side with the face which bolts to the bed downwards, and a print is screwed on this joint face to carry a portion of the lightening core. One pattern will suffice for both standards, by reversing the parts from one hand to the other. The core will cut through on the bottom—the top—the joint face, and on the slide, but no prints will be required save that one on the joint face just mentioned, which bolts against the machine bed. Elsewhere the core will be supported and steadied by chaplets. In nearly all large hollow machine castings chaplets furnish the chief support to the cores, prints being available to but a limited extent. In their rudest form they are simply thin plates of hoop iron, into which a bit of wrought bar of the necessary length is riveted, the opposite end of the bar being steadied against a bar of the box, or a cubical wooden chaplet block embedded in the sand (Fig. 405). These chaplets, arranged at the discretion of the moulder around the otherwise unstayed portions of a core, effectually prevent the liquid pressure of the metal from thrusting the core against the side of the mould.

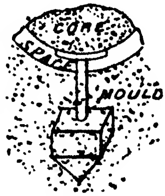


Fig. 405.

The core-box for the main core of the standard will be

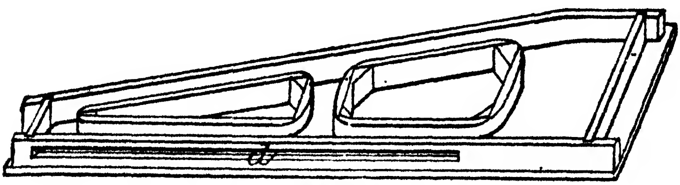


Fig. 406.

made as shown in Fig. 406. It is very similar in appearance to a pattern partly boxed up. The strips which form the

bottom of the box may be battened together, and should be at least 1½ inch thick. The sides will be abutted together first, and then after being sustained with stout blocks glued and screwed into their angles the radii will be worked, the whole of this portion of the box being kept in position on the bottom board with dowels. The groove for the nut for the vertical screw is cut through the side of the box at *d*. This core does not include that which cuts through the joint face block. This will be made in a distinct box, similar to Fig. 403, and laid in the mould first, the main core being subsequently laid upon it.

Looking at the travelling table (Fig. 407) we see a recessed portion at each end dropping a little below the T-headed bolt

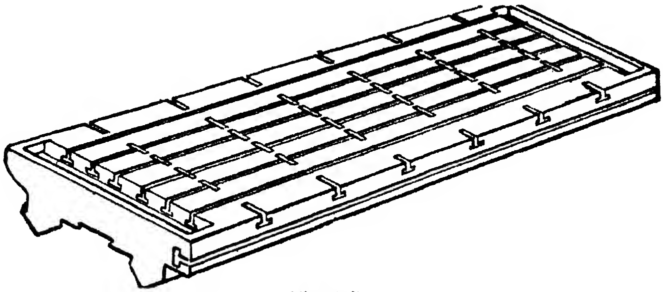


Fig. 407.

recesses. We shall take advantage of this fact, and make our table in such a way that it cannot get out of truth. The plate will be formed of two thicknesses of stuff, the lowermost thickness being equal to the plate at its thinnest (Fig. 408, *a*),

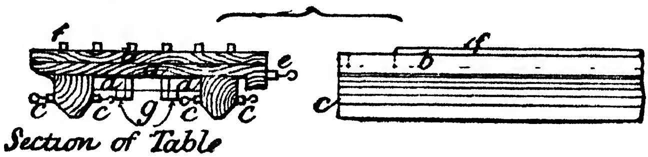


Fig. 408

the uppermost equal to the thicker portion, *b*. The thinner pieces will be equal to the table in length, and sufficient in quantity to make up the width. We shall not glue these pieces edge to edge, but joint with open joints; that is, leave about ⅛ inch between each strip of timber. If we were to

glue our pieces together in a pattern so wide, a few hours of exposure in the damp sand of the foundry would expand the wood sideways, and either make the pattern too wide or else curve it. The open joints allow of localised extension, and so the bounding edges of the pattern remain unaltered. On the lower longitudinal pieces thus jointed, screw in a transverse direction sufficient stuff to form the thicker portion, *b*, also with open joints. We shall thus have a rigid table that will not go out of truth either by the action of damp or heat.

Upon this we put the remainder of the work, very simple indeed. The long V-shaped sliders have narrow planing strips wired on their sides (Fig. 408, *c*, *c*). Strengthening ribs are often placed crosswise underneath on heavy tables, *d*, *d*. Sometimes in the larger machines the sliders are lightened out at intervals with rectangular holes, in which case pocket prints on both sides will be used. A T-headed groove is run along one edge (frequently along the bottom) to receive the tappets. The core for this will be fixed by a print wired on *e*. The prints on the face of the table, *f* (Fig. 408), for the T-headed bolts, need only be shallow, ½ inch or ¾ inch deep, and the cores will be made in short lengths, say 18 inches or 2 feet, placed end to end, as also will be those for the tappet groove. It will aid the moulder if all the work on the under side, sliders, and ribs is left dowelled, to come away with the top sand, rather than that the top sand should be dragged away from them. The lugs, *g*, *g*, are for attaching the travelling rack to.

Fig. 408A.

'Wadkin" Worm Milling Attachment in Operation.

CHAPTER XXII.

WATER WHEELS AND TURBINES.

Water-wheels.—Their Bosses.—For Flat Arms.—For Round **Rods.**—Shrouding.—Toothed Ring.—Building it up.—Marking out.—The Teeth.—Turbines.—Core-box for Buckets.—Mode of forming the Shrouding. Core-box for Guide.—The Discs.—Greensand and Loam Moulds.—Turbine Steps.—Lignum Vitæ Strips.—Directions for fitting in.—Governor-ring.

WATER-WHEELS do not come within the range of the pattern-maker's work to the same extent that they formerly did. For, in addition to the fact that the smaller and more economical turbines are largely taking the place of the more cumbrous and extravagant water-wheels, there is also the circumstance that cast iron enters but slightly into their construction. But the fact that there is some cast iron about them, and that the country workman is not unfrequently called upon either to construct or to repair an existing wheel, justifies some slight allusion to the principal parts.

In the first place, then, the structure of the central bosses will vary according as the power is taken from the centre or from the circumference of the wheel. If it be taken from the centre the torsional strain is great, and stout wrought or cast iron arms will be used. Then the boss will have recessed pockets (Fig. 409) to receive the ends of the arms, and the pattern, but for the central print, will be exactly like the casting. The bits, *a*, *a*, *a*, are chipping strips to allow of

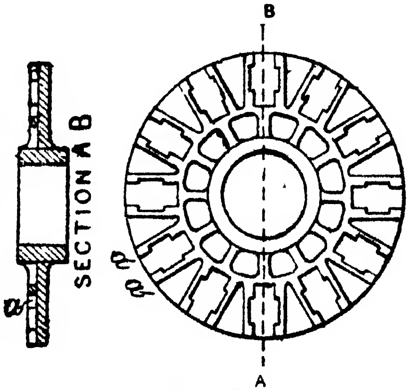


Fig 409.

accurate fitting of the arms without chipping the edges of the recesses along the entire length. But when the power is taken from the circumference there is very little leverage, and round wrought bars serve both as arms and struts. Then the central bosses take the form of Fig. 410, having arm and strut bosses and cottar ways, *a*, *a*, for the attachment of the rods.

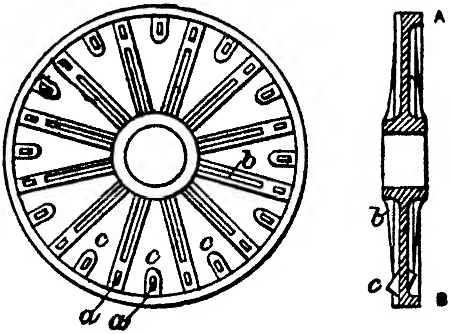
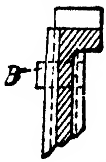


Fig. 410.

In making this pattern a plain plate is turned, of the correct diameter, and with a strengthening rib built up at the circumference. The central bosses being turned and screwed on, the long bosses for the arms are abutted against them. These are turned as indicated in section, Fig. 411. A represents a middle strip planed to the same thickness as the plate itself; B, B represent the actual boss pieces laid against each side of this strip, and held temporarily with screws, as when jointing pattern stuff in halves. The three are thus turned together, and the middle piece being removed, the boss pieces are ready to screw in their places and form a circular section with the plate itself. The pieces marked *b*, *b*, Fig. 410, are mere strengthening ribs fastened upon these bosses exactly as required in the casting.


Fig. 411.

On the periphery long pocket prints are fastened, Fig. 412, and on every boss a cottar way print, B. The two prints carry



Enlarged view of pattern at A *on Fig.* 410.

Fig. 412.

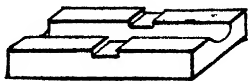


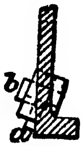
Fig. 413.

the arm core with its cottar ways, made from a box, one-half of which is shown laid open in Fig. 413.

The bosses, *c*, *c*, *c*, *c*, Fig. 410, are for the strutting arms, and these are best turned from the solid, and sawn all alike to a bevel. On these also pocket prints, Fig. 414, *a*, and cottar

way prints, *b*, are fastened, for which a short core-box similar to the last will be made.

The shrouding of a wheel (Fig. 415) will also vary with the conditions under which the power is taken off. Round rods will require cottared bosses, and these will be made and cored similarly to those just described on the central boss. Flat arms will require recesses like those on Fig. 415, A.



Enlarged view of pattern at B *on Fig.* 410.

Fig. 414.

When making the shrouding plate it is desirable, where the wheel is large and the number of segment pieces considerable, to make the pattern plate of cast iron, or, better still, of a piece of thin wrought-iron plate, and to screw upon this the curved

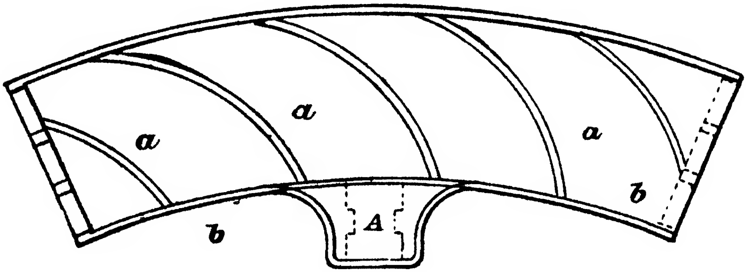


Fig. 415.

flanges, *a*, *a*, either continuous, as shown in the figure, or disjointed, for the attachment of the buckets, and the inner flange, *b*, for the attachment of the sole-plate.

Where a ring of teeth is bolted round the shrouding, much care is necessary in the preparation of the pattern. Without due care the segment castings may come out long or short; they may be atwist, their ends may not be radial, and their teeth may not be square—for all of which errors the pattern-maker will be held responsible.

The correct length of the segments is obtained by calculating the length of a chord of the circle* if the wheel be

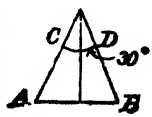


Fig. 416.

* The chord is obtained thus. Find the half angle of the included space betweeen the radii. Get the sine of that angle from a table of natural sines, multiply the radius by the sine. The product doubled gives the required length of the chord. Thus, let it be required to know the length of the chord A B, Fig. 416, A B being the twelfth of a circle whose diameter is 16 feet. The angle at C D is 30°, one-half of which is 15°. The sine of 15° is ·25881. The radius is 8 feet. Then ·25881 × 8 × 2 = A B = 4′ 1·69″.

large, or by striking out a portion of the entire ring, say $\frac{1}{8}$ or $\frac{1}{4}$, if the wheel be small, and giving the segment its proportional part of the arc thus struck out. We allow for fitting on the ends of the segments, which with all due care may vary $\frac{1}{8}$ or $\frac{1}{4}$ inch in length in the castings. The allowance is made for chipping by means of narrow strips ("chipping strips") about $\frac{3}{4}$ inch or 1 inch wide, and they are made thick enough to allow for all possible variation in the casting, say $\frac{3}{8}$ inch in this case at each end, and of this amount at least $\frac{1}{8}$ inch is allowed at each end over and above the finished length of casting, to be taken off by chipping. And as the shrouding plates are not likely to be true, and the segment may become rammed winding, we also put chipping strips on the bottom face of the segment, giving a similar allowance there for fitting.

This ring may be either internal or external, according as the teeth are on its inner or outer curve; but in either case the pattern is made as follows:—

Having struck out the segment in plan (Fig. 417) to get the

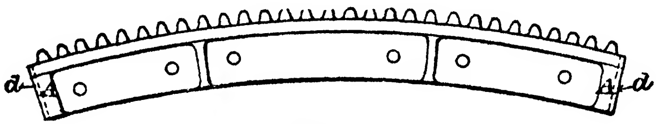


Fig. 417.

ends truly radial and the teeth of the correct shape, and in section also (Fig. 418), we prepare segments for the purpose of building up the sweep. The plate of the segment (Fig. 418, *a*) can be made either in one piece or in two or three sets of sweeps, the latter being, of course, the better method of the two. The thin portion, or the rim, will be made in segments, ceasing at *b*, just where the hollow, *c*, commences. The thickness which forms the hollow, *c*, will be cut out separately—then these three parts, the plate, the rim, the hollow—each distinct and separate, but gauged to thickness, will be screwed together temporarily in the rough. The segment, though rough externally and internally, is at this stage complete in its thickness and ready to receive the lines.

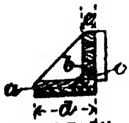


Fig. 418.

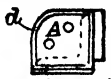


Fig. 420.

Strike the line* on one side for that curve of the ring on

* When striking large radii a trammel-rod is apt to spring and cause a wavy line. In such cases it is better to screw a couple of straightedges

which the teeth are to be fastened, and mark the ends radially from the centre of the curve so struck. Remove to the vice and plane these ends square with the parallel planed top and bottom faces. Then laying the segment on its face upon a true bench or drawing-board, square over with set square the curved line just struck on to the opposite side, and mark the sweep again on that side also. Work this sweep from one side to the other, roughing with gouge and finishing with planes. We have thus a true curve for the attachment of our teeth, at right-angles with the base of the segment. Now, taking out our temporary screws, we can gauge each of the separate portions of the segment, the plate (Fig. 418, *a*), the rim, *b*, and the hollow, *c*, and work them separately—returning them into position and gluing and screwing permanently when done. We shall work the teeth in a box, and glue and brad on. The segment ends, A, A, Figs. 417, 420, will be fitted into the angle formed by the plate and the rim, and their chipping strips, *d*, *d*, fastened on, excepting the one in the bottom, which will be skewered. Holes in the ends for bolting the sweeps together will be taken out with pocket prints.

Turbines (Fig. 421) are now in extensive employment in England as in Continental countries. They vary much in design, but differ essentially from water-wheels in that the axis is often vertical, and the turbine therefore revolves in a plane parallel with the horizon. The principal type is that which consists of an inner ring of guides, A, A, and an outer ring of buckets, B, B, usually in two or three vertical tiers connected with shrouding, *a*, *b*, *c*, *d*. Turbines being very small in comparison with water-wheels, both the buckets and their shroudings are formed in one casting, the guides and their shroudings being also formed in the same way. Now if we look attentively at our ring of buckets (Fig. 421, plan B), we shall

together like Fig. 419, and slide them around two fixed pins set in the course of the circle at the extremities of the chord, and with a scriber held against the apex describe the circle. The condition is that the height of the triangle measured from the chord shall be equal to the versed sine of its circle, which versed sine is obtained thus:

$$V = R - \sqrt{R^2 - C^2}$$

In which R = radius
C = semichord.

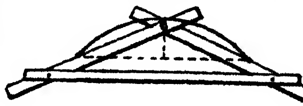


Fig. 419.

I prefer this to the methods of intersecting lines given in books on geometry.

see that the labour of making a pattern would be immense. To cut the shroudings and all the buckets would be a round-about task. But the buckets being all alike, cores sufficient

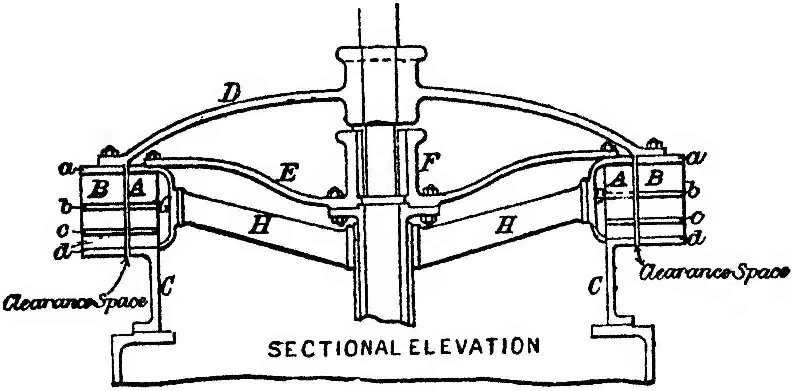


Fig. 421.

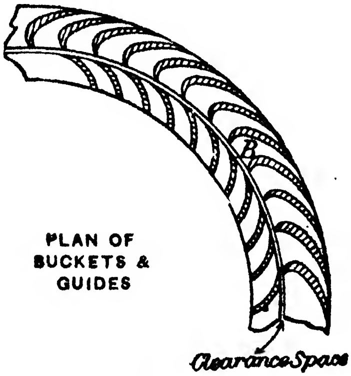


Fig. 421.

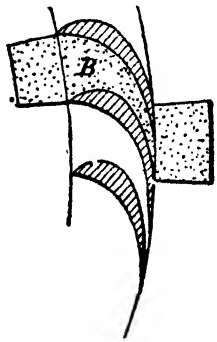


Fig. 422.

for an entire course of buckets can be made from one core-box (Fig. 422); and if there are two or three courses, we need but two or three core-boxes, in which core-boxes the shrouding can also be made. Considering again for a moment, we see that not only will no pattern be necessary, but that no prints for these cores will be wanted, for if the cores be made to fit one another closely without and within the circle of the buckets, they will close up the mould (Fig. 423). Then all

we need do is to strike two circles corresponding with the inside and outside ends of the cores, C and D, upon a sand-bed, and to set the cores by these lines. Having thus cleared the way, let us go into detail.

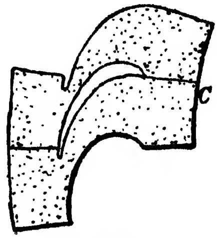


Fig. 423.

Fig. 424 illustrates the way in which the core-box is made. Construct a plain rectangular core-box, as indicated by the outer lines. Into this fit sundry blocks, *a*, *a*, *a*, *a*, to part at *b*, *b*. Make a templet of the core in thin wood, and laying it on one side of these blocks, scribe round its edges upon the box face. Open the box, square down in the joint, place together again and scribe off from the templet on to the other side. The box may then be pared and planed through. We might make the box of the entire depth of the three rows of buckets with their

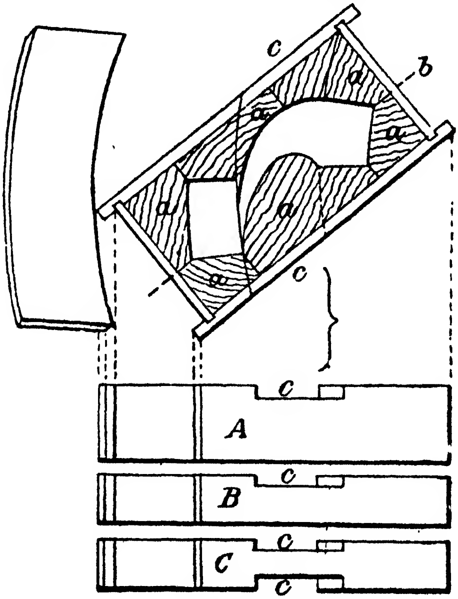


Fig. 424.

shrouding, but that would cause inconvenience, since the intermediate shrouding, or rather plating, would be formed through the heart of the core, and being only ¼ inch or ⅜ inch

thick, there would be no chance to get at it for the purpose of cleaning up or blacking; so we prefer to make as many core-boxes as there are rows of buckets, A, B, C.

Then for the shrouding we get out sweeped pieces (Fig. 424), corresponding in section with the shrouding and plating, and having marked carefully their concentric positions on the faces of the boxes we cut out recesses, *c, c, c, c* (Fig. 424), on those faces for their reception. Hence, when a core is made, say core A, it presents the appearance of Fig. 425. When the three rows of cores are made and put together we get two shrouds, two plates, and a metal space between contiguous cores. The cores being arranged in a circle, sand is rammed around them to afford support, and a loam top covers the

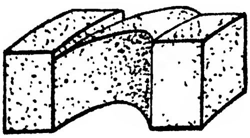


Fig. 425.

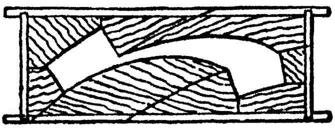


Fig. 426.

whole. The metal then flows between the cores to form the curved partitions between the buckets, and through the cores to form shrouding and plating, while at the outer and inner terminations of the buckets its flow is arrested by the abutting ends of the cores.

The same method is adopted for making the ring of guides, in which the core-box will be shaped like Fig. 426. The cylindrical seating for the governor, with its flange for bolting to the inlet pipe (Fig. 421, C, C), is shown cast in a piece with the guides, and for this two boards, shaped respectively like the Figs. 427, will be made, the seating being cast uppermost.

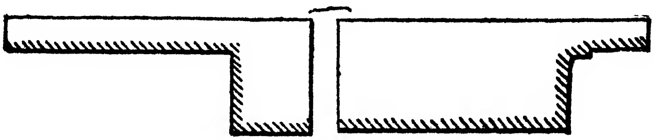


Fig. 427.

The dished plates (Fig. 421, D, E), to which the buckets and guides are respectively bolted, would be made from patterns if small, but struck up if large. Either greensand or loam may be used in the latter case. If greensand, the boards will be

cut as in Fig. 428; if loam, like Figs. 429, 430—the difference between the two being as follows: In a struck-up greensand mould the top board cut to the dotted line, *a*, *a*, *a*, *a*, in the Fig. 428, strikes a bed of hard rammed sand, which, being sprinkled with parting sand and covered with a top box has a reverse sand mould rammed upon it, a thing easily and constantly being done, since the lower sand is rammed sufficiently

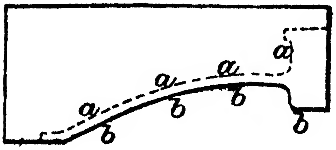


Fig. 428.

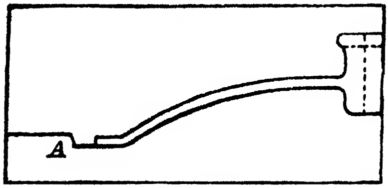


Fig. 429.

hard to resist the thrust of the hand-rammer. This being lifted away, the board cut to the full line, *b*, *b*, *b*, *b*, strikes out the thickness of metal to the bottom edge. The top box then closes this bottom mould for casting. The disadvantage of this method is, that square edges—that is, edges of sand standing approximately vertical—cannot be lifted in greensand without becoming torn away and broken down, so that mending up with sweeps becomes necessary. Where this occurs the best way is to make the board to strike the edge at

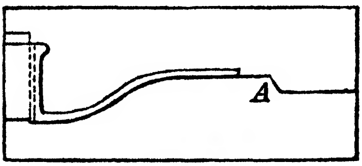


Fig. 430.

Fig. 431.

an angle from which the sand will lift without fracture, ram the top box on that, and then make the edge in the top square with a sweep. We then have an unbroken lower edge by which to guide the mending-up sweep (Fig. 431). The advantage of adopting a greensand mould is, that the time occupied in bricking up and drying are both saved—items of so much importance that a loam mould which would occupy perhaps four days in making could be done within a day in green-

sand. There is of course a large class of foundry work which must be done in loam; but where the option lies between the two, the difference in cost will induce us in such cases to decide in favour of greensand.

A comparison of the figures illustrates the difference in method, for in the loam mould the boards strike the actual opposite faces in both top and bottom, while in the greensand the bottom face only is directly struck. When the moulds are closed, the checks, A, A, insure their concentricity.

The guide-ring plate, E, carries the step bearing of the turbine shaft (Fig. 421, F), and the step of a turbine is lined with strips of lignum vitæ (Fig. 432), which, with the water for a lubricant, answers better than metal. These strips are driven tightly into grooves, *a*, *a*, *a*, cast in the boss (Fig. 433). These recesses, if cut out in the pattern, are so deep, and the spaces between them so slight, that they would not deliver from the sand. Hence we core them out, as indeed we should do in the case of any other recesses or pockets where accuracy is required. But neither could we put prints around the inside of the boss, since the thin sand between their edges would not hold together. So the correct way is to put a round print upon the centre of the boss just as though there were nothing but a perfectly plain core wanted. Then we make a core-box for the recesses, distinct from the main central core, of course with no print allowance, and the sides of this should have a shade of taper from the upper end, so that the strips shall have a tendency to tighten as they are driven down. When the cores are dry the pattern-maker marks off as many equal divisions on the central core as there are to be recesses in the casting, and nails the recess cores upon the central one (Fig. 433), which is then ready to be dropped bodily into the mould.

Fig. 432.

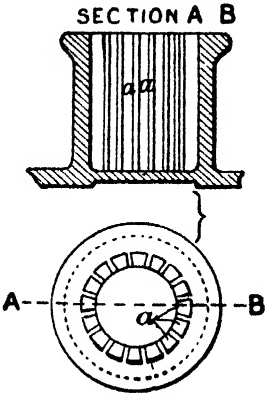


Fig. 433.

The pattern-maker is also expected to fill in the lignum vitæ blocks, and this should be effected with as little waste of

stuff as possible. The best plan is to cut the stick down with a circular or frame-saw to the thickness required, and then, having fitted a templet strip into the casting and made the necessary allowances for turning and facing, to mark out the thicknessed stuff from that. Once sawn out, the pieces should be kept in a cool place or in water while being worked up, as lignum vitæ is particularly liable to shake in the joints of the annular rings. When driving in, care should be taken not to strike on the shoulder (*a*, Fig. 432), or it will infallibly split off. When all are driven in, the step will go into a lathe having a slide-rest, to be bored and faced.

The governor-guide (Fig. 421, G, G), is either cast in a piece with the arms or bolted to them afterwards, the latter plan being preferable. A small guide would be cored out with

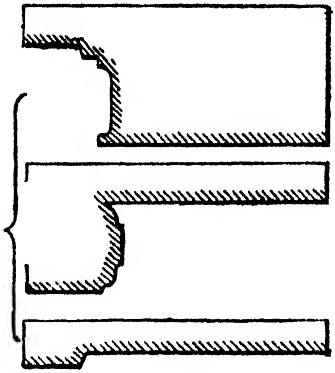


Fig 434.

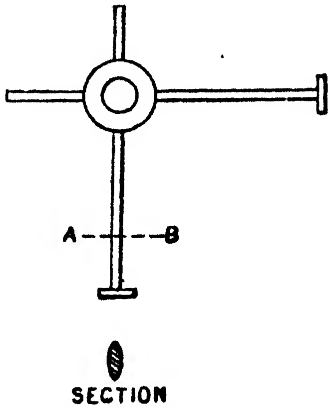


Fig. 435.

segmental cores, a large one struck in loam, for which the boards will be like Fig. 434. The arms (Fig. 421, H, H) are planed up oval-shaped and mortised into the central boss (Fig. 435), and have their flanges screwed on, everything being fast, and the moulder joints down to the centre of the oval section.

CHAPTER XXIII.

SCREWS.

Principle of the Screw.—Diameter.—Pitch.—Striking out.—Entire Patterns.—Fitting the Segments.—Working to Shape.—Pile Screws.—Propeller Screws.—Marking out.—Pattern Blades.—Loam Screws.

Screws will range from a few inches in diameter up to several feet. They will contain several revolutions, as in those for corn elevators and brick machines; or a single revolution only of the blade, as in pile screws; or fractional portions of two three, or four helices, as in propellers. We can also mould them from patterns, or strike them up in loam. To a young hand a screw appears a most difficult task—a veritable donkeys' bridge, the *Pons Asinorum* of his craft. How to get the necessary lines is by no means clear, nor, having got them, how to work the blades. But if the fundamental principle of the screw be borne in mind, viz. the development of an inclined plane around a cylinder, no real difficulty need be experienced in work of this kind. Details will vary, and a considérable degree of accuracy will be requisite, but a screw is only a screw after all, no matter how it may be modified.

The diameter of a screw is measured across the tips of the blade (Figs. 436, 437). The pitch is the distance between the

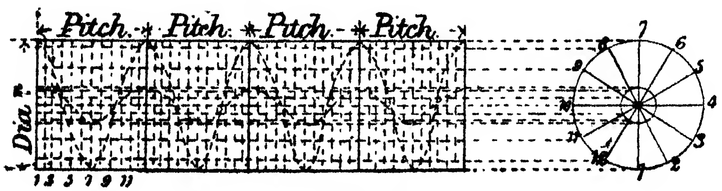


Fig. 436.

centres of the blade when it has made one revolution (Fig. 436). So that a piece of paper shaped like an inclined plane,

equal in length to the circumference of the screw, as wide at one end as the pitch of the screw, from thence tapering to a point at the other end, will, when wrapped round a cylinder

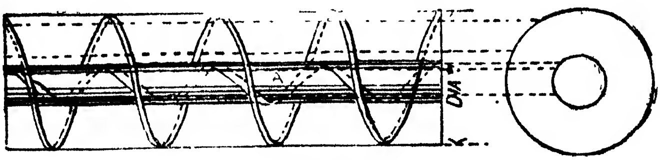


Fig. 437.

of the proper diameter, form a helix around its circumference. Similarly any number of revolutions could be formed by describing corresponding lines on a sheet of paper long enough

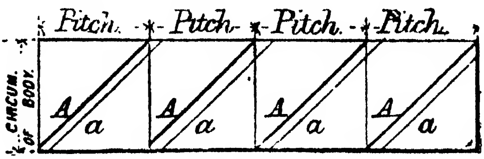


Fig. 438.

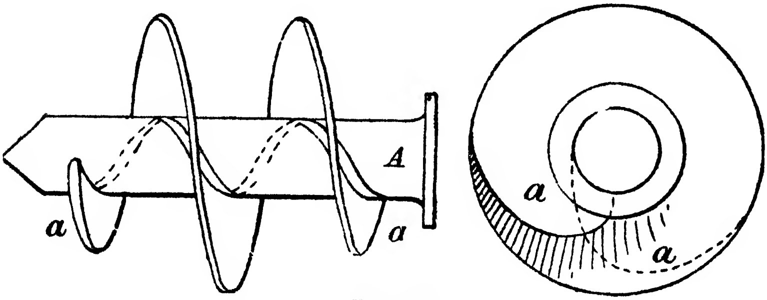
to embrace the total number required, such lines to fulfil the condition stated above, and to run parallel with one another (Fig. 438, A, A, A, A).

But this, though a correct and ready method in the case of small screws, would not be quite so practicable with those of large diameter which are not cut from a solid cylinder. Some other method is desirable, and the following answers for a screw of any diameter, and also for the projection of the screw on the drawing-board.

Divide both the circumference and the pitch into the same number of equal parts (Fig. 436)—10, 20, 50, it matters not, so that they are equal; but the greater the number of divisions, the more accurately will the screw be lined out. Through the successive intersections of these lines draw a diagonal, right or left handed, as required, and this will represent the line of the screw thread—either its edge or centre, whichever we choose to elect (Fig. 436).

If we had to make a screw either with one or with several revolutions and of small diameter, we could cut it out of the solid stuff, as we do in the case of the worm. But such a course would be open to this objection—that the fibres of the grain would be no longer than the thickness of

the screw blade, and our pattern would become damaged or broken by a very slight amount of ill-usage. Hence a better way—the correct way, in fact—is the following. First joint, dowel, and turn up the body of the pattern, *i.e.* the solid portion round which the helix turns (Fig. 437, 439, A, A). Evidently the pitch of a screw at the base must be equal to the



Figs. 439.

pitch at the point. So we mark our inclined planes diagonally across, uniting the lines which represent the pitch, with the edges which complete the circumference, on a piece of paper of the breadth of the screw body, and of length equal to its circumference (Fig. 438, A, A, A, A). Parallel with these lines, and at a distance from them equal to the thickness of the screw at the root, we mark other lines, *a*, *a*, *a*, *a*, and then glue the paper round the turned body. The space inclosed by these parallel lines represents the width of a groove which is to be channelled out about $\frac{3}{16}$ inch deep, with saw, chisel, and

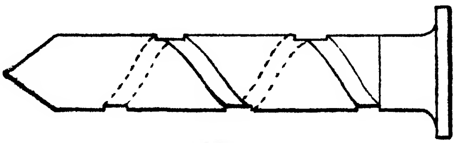


Fig. 440.

templet, to receive the actual screw. When the groove is cut the body will have the appearance of Fig. 440, which represents the body of the pile screw (Fig. 439).

Then for the actual thread, get out a number of segments roughly, like miniature propeller blades, long enough to reach from the bottom of the groove to a little beyond the screw tip, say $\frac{1}{2}$ inch, and a little thicker than the thickness of the screw at the root or base. The width will be immaterial—say a

sixth of a revolution each in a small pattern, a tenth or a twelfth for a large one. Let the grain fibres run towards the centre of the screw's diameter to afford the greatest strength (Fig. 441), which represents three such roughed out blades. Each of these pieces must now be fitted in succession with gouge and chisel in the grooves previously cut, and the centre line of each piece should stand approximately square with the axis of the screw body. As these are fitted in succession they must be held in place by means of screws run in from the *joint* of the body. When the desired revolution or number of revolutions is complete, replace the body in the lathe, and turn the edge of the blade to the proper diameter, holding the tools with a firm grip to avoid a smash.

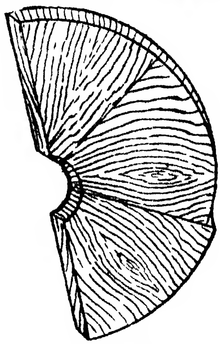


Fig. 441.

This being done, mark on a strip of wood the number of divisions into which it is intended to divide the pitch (Fig. 442); lay this on the lathe rest, and with a timber scribe set off corresponding lines on the revolving pattern. Then divide the circumference into the same number of equal parts as that into which the pitch is divided. Through the successive intersections of these lines draw a helix by means of a narrow blade of thin steel bent around the edge (Fig. 443), which represents the pattern at this particular stage. Previous to marking these divisions, especial care should be taken that we start square with the body. A good way to begin at right angles is to take the pattern out of the lathe before marking out the point of the thread, unfasten the joint, and mark a centre line on the blade *in the joint* with a square. This produced to the outside will form a correct starting-point for the subsequent dividing out.

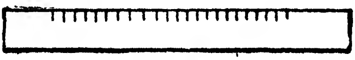


Fig. 442.

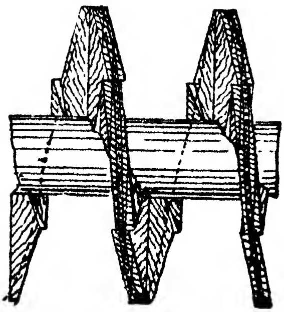


Fig. 443.

The thickness of the screw at the tip will be pricked with compasses and marked equidistantly from the centre line, using the bent steel, as before, to run the lines round. The

segments forming the helix will then be all unscrewed at the joint, and one by one worked to shape. This simply consists in cutting *straight* outwards from the thickness of the root, given by the width of the groove, to the thickness at the tips last marked (Fig. 444). A rebate plate, slightly rounded on the face, is the best tool for this purpose, and the work must be tried with a straight-edge from time to time, to be assured that every line running to the centre is straight, and not rounding or hollow. Clean up with glasspaper and replace in groove.

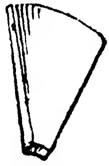


Fig. 444.

If our screw be a small one, say of not more than 10 inches or 12 inches in diameter, these blade segments can now be finally and permanently fixed in place. For a small screw, even though it has a good many revolutions, can, if worked carefully, be drawn, or rather screwed, out of the sand by a spiral twist. But if the screw be one of two or three feet in diameter, the friction of the sand against its sides is much too great to allow of this. In such a case each segment must be drawn separately. This is only possible by allowing the radial joints full freedom to slide over one another; hence screws and brads cannot be used to keep those joints flush in the mould. Yet they must have some steadiment during the process of ramming up, and this can be afforded by an oblong dowel at the tip of the thread (Fig. 445). Each segment piece which contains the dowel-hole can then be drawn out, followed by the piece containg the dowel. The screws in the joint of the body retain the segments in their grooves during ramming up. After they are drawn, the body is lifted out and the segments follow singly.

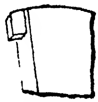


Fig. 445.

The taper of the pile screw (Fig. 439, *a*, *a*) is given after the screw is worked. It is marked round with a pencil, the eye judging of its shape, or the entire circumference may be divided into a number of equal parts, and in each division, beginning with the first, a corresponding division will be pricked, proportional with the required amount of taper.

In making the pattern for a propeller screw, precisely the same principles of design will guide us as in the previous case, but our mode of working will be greatly modified.

Say we have to make a common screw of 6 feet diameter and 12 feet pitch, by pattern. It may be two, three, or four-bladed, that is, it will contain segmental portions of two, three, or four helices. Our first care is to strike it out. Fig. 446 shows

a three-bladed propeller, though not a working drawing; for in practice it is not necessary to strike out the whole screw.

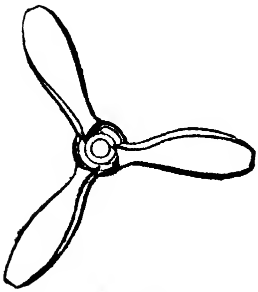


Fig. 446.

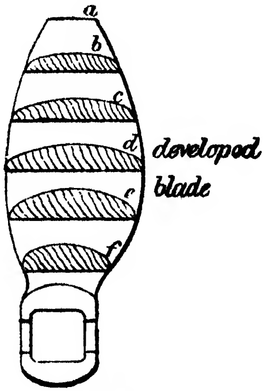


Fig. 447.

All we need take is some aliquot part of the circumference, and a corresponding proportional part of the pitch, from which to get our data. Usually we want the angle at tip of screw, and a single developed blade with a boss section. The blade is developed as shown in Fig. 447 in order that the pattern-maker may prepare his templet strips for the guidance of the moulder, those strips corresponding in shape with the sections drawn across the blade. The angle at tip is required so that a templet may be cut for the building up of a pattern blade, or a sheet-iron guide made for the striking up of a loam bed. Imagine the circle formed by the tip of the screw to be unrolled—that is, take the circumference of the circle, in this case 18 feet $10\frac{1}{16}$ inches, and let that form the one side of a right-angled triangle (Fig.

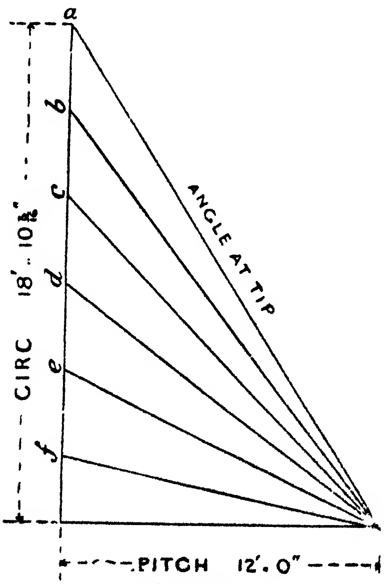


Fig. 448.

448), the pitch of the screw, 12 feet, being its base; then the angle the hypothenuse will make with the side will represent the angle of the tip of the screw.

This need not, however, be drawn to full size, since in equally proportioned triangles the corresponding angles are equal to one another. So we can make it to any convenient scale, and measure upon it the actual breadth of the screw blade, and divide into as many parts as we divide the radius of the screw into, *a, b, c, d, e, f* (Fig. 447). These lines will represent the respective angles made by the screw sections at those points.

When a pattern blade is made, it is built up in overlapping strips, as shown in Fig. 449. The strips, it will be observed, are planed to a uniform thickness of ¾ inch or 1 inch, so that when glued together their squared edges form an exact guide for the dressing off to shape. Work from end to end with planes, remembering, as before, that every line running from centre to circumference is straight. If the pattern blade is to be used for casting an entire propeller, the most convenient way of doing so is to make a core-box, put the blade into it, and make as many cores as we require blades. The thing to be noted is that the angle at the segmental boss is suited to the number of blades, 90° for 4 blades, 120° for 3, &c. If a core-box is not used, the blade is attached to a centre bar, and rammed up as many times as there are blades in the propeller. Movable top plates, or drawbacks, are used to carry the sand over the blades.

Fig. 449.

There are variations in the methods adopted in sweeping propeller screws in loam, and those in general use are shown

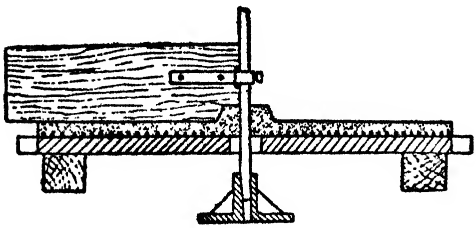


Fig. 450.

in the following figures. In Fig. 450 a cast-iron plate is seen laid down, with a centre bar to which a plain board is attached to sweep up a level bed to form a basis for the mould for the

blades, and a raised centre piece to support the mould for the boss. The bed is dried, and on it outlines are drawn to correspond with the number of the blades, four in this case. The next stage may be the sweeping of the boss, if this is done in

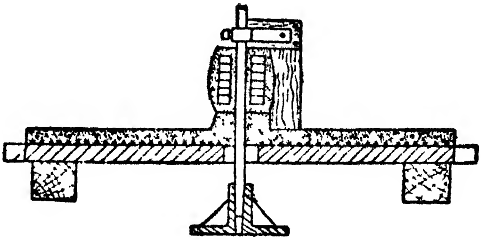


Fig. 451.

place (Fig. 451). Or it may be swept against a horizontal board away from the bed, using haybands instead of the bricks. This is a pattern boss against which the boss mould is formed during the sweeping of the blades.

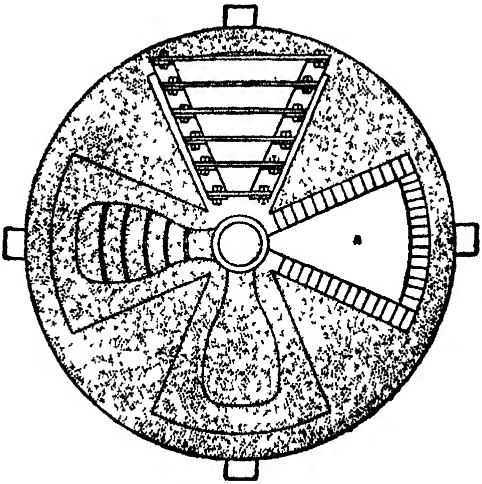


Fig. 452.

Figs. 452 and 453 show alternative forms of plates. The first is suitable for the smaller moulds, the second for the larger. Or separate plates can be cast, one for each blade and bolted on a circular stock-plate.

The building up of the blade moulds is done as follows : A templet for the slope of the pitch is prepared either in sheet-iron or wood. The latter is preferable because a broad base can be made to support it steadily. The edge is cut to the angle of the face of the screw—the hypotenuse of circumference and pitch. It is laid down in succession for the bricking-up and sweeping of the bottom moulds, which are those of the flat faces of the blades. These are enclosed with brickwork, built up and surrounding the outlines marked on the swept bed, Figs. 452 and 453, A, and Fig. 454, with ample margin for loam beyond the edges of the blades. The bricks, bedded in loam, may be any broken odds and ends, and the joints

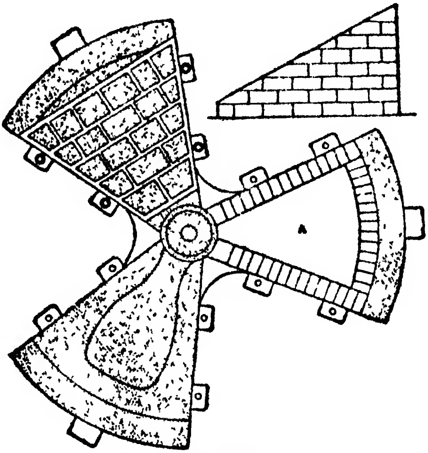


Fig. 454.

Fig. 453.

must be open for free venting. The cementing loam is coarse The walls will follow approximately the slope of the pitch templet, but will stop short of the top edge by about 1 inch to leave room for a thickness of loam.

The loam is swept with the board (Fig. 455) resting on, and guided by the edge of the pitch templet, and moved up it. All the central space between the bricking is occupied with cinders and small pieces of broken brick, and over it pieces of loam bricks are set up to the level of the outer walls. Stiff loam is used for setting these in, and a coating of rough loam is laid over them, followed by a fine coat to be finished with the board, for which several passes will be required. The mould is then dried in the stove or with heaters.

The board (Fig. 455) is braced and has two places of attachment to the sweeping bar. This prevents it from sagging, which would be liable to occur with a single plain board. The lower striking edge must be truly horizontal, which can be tested with a spirit-level. As the weight is counterbalanced, a roller is not necessary to run on the edge of the guide-piece, but it may be fitted. A piece of hoop iron is often screwed along the lower edge of the board for greater durability. The positions of the templet pieces that give the thicknesses and

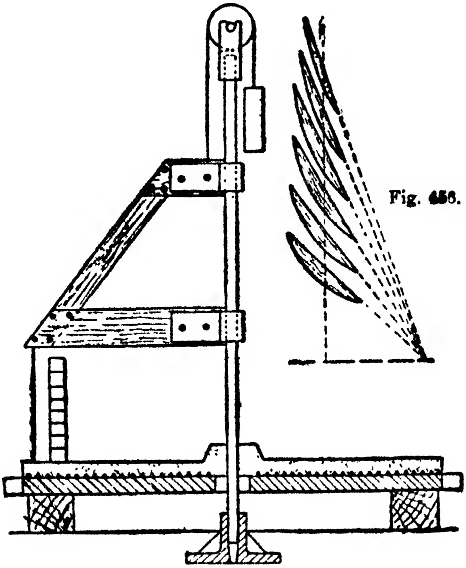


Fig. 456.

Fig. 455.

contours of the blade in different positions are often scribed on the edge of the board, and their positions on the mould face marked therefrom.

The sections of the blade at several different radii are taken from the office drawing (Fig. 456), and a templet of wood or zinc is made for each. These are laid on the mould bed and secured with dowels or nails (Fig. 452). The interspaces are filled with sand, strickled off level with the curved upper edges, so forming a dummy mould, on which, after parting sand is dusted, the top will be prepared.

Each blade has its separate top part. This in the smaller propellers may be a light grid built up of crossing rods, bolted to a top plate, which must be horizontal for loading. The rods come to within an inch or so of the face of the mould. Or the top may be built up, as shown in Fig. 452, of separate ribs bolted together to follow roughly the outlines of the joint face, and of the blade sections. Or a box part may be cast as in Fig. 453, suitably sloped on the face to fit the loamed joint face. The interspaces are filled with pieces of loam bricks or loam cake, and coarse loam. Loam is worked over the face and pressed down on the prepared bed. The loam is allowed to set in place and the process repeated with a finer coat. It is set with heaters, after which the top is lifted, cleaned, blackened, and put in the stove to be dried. This will be repeated for each of the blades. The templets, and the sand of their interspaces, will be removed from their beds, and the faces of the latter cleaned and blackened.

The tops may be either weighted for pouring, or bolted down as in Fig. 453, which is the better method. Lugs are cast to receive them in the cope sections, and in the bottom plate. Pouring is done through the boss. A large vent comes out from the central core. The entire mould is set in a pit for casting. It is rammed all round with sand to prevent possible risk of a run-out occurring. A flow-off gate is provided, a large excess of metal is poured, and the boss is fed.

Separate loose blades can be swept up and their tops rammed by similar methods. The same striking board and form of cope is used, but a single square plate takes the place of the circular plate employed for a complete propeller. Blades are made in separate cores when they are of moderate dimensions, and the propeller is of a size that is often required. A pattern blade is prepared with a section of the boss. The box is jointed to suit the twist of the blade. Each half is rammed on its grid. The cores are set in position on a levelled bed, with stakes, and rammed round.

The method of sweeping a face for a moulded blade can be adopted when making a pattern blade of wood. The pattern, glued up with overlapping strips, is laid on this as a templet from which to work the face by. Then the sectional forms are cut to templets of the reverse shapes from those employed in making a mould.

CHAPTER XXIV.

CHILLED WORK.

Theory of Chilling.—Trolly-wheels.—Curve of Disc.—Chill.—Top Box.—Roller.—Jointing of Chill.—Wheel Naves.—Clips.

The art of chilling castings properly is only to be acquired by long experience and observation. The theory is, that by the chilling of a casting the separation of the graphite from the iron is prevented, and combination takes place instead. The essential thing is so to mix various classes of iron together that a chilled face penetrating to any required depth may be assured. Consequently, it is somewhat of a trade secret; those who know how to chill keep the results of their experience to themselves. But, as regards the pattern-maker, the only knowledge necessary to be imparted is how to make due provision for patterns whose castings have to be chilled.

A chilled surface results when molten iron is run against a cold metallic mould. The crystals of metal invariably arrange themselves at right angles with the cold surface, and they become white, hard, and of a steely nature. The regularly crystallised portion may extend from ¼ inch to ¾ inch in depth, and presents a most characteristic section when broken along the course of the needle-like crystals (Fig. 457).

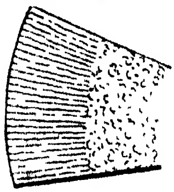
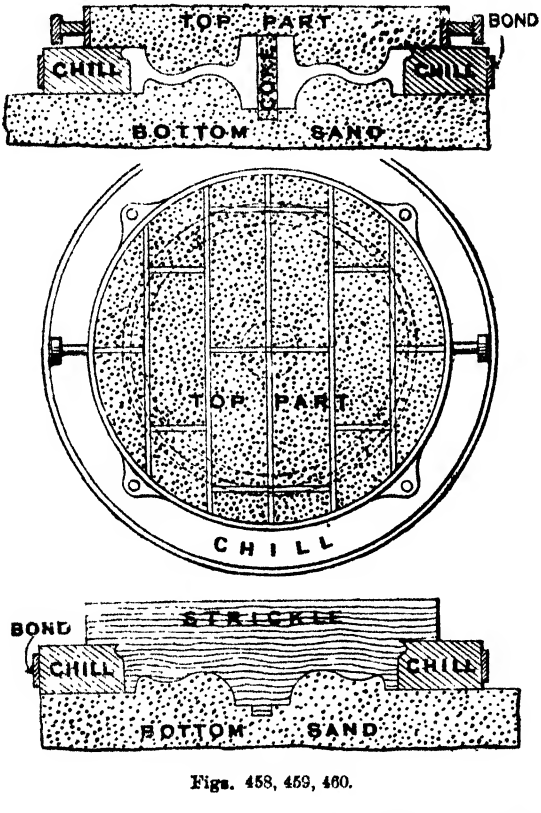


Fig. 457.

Take a simple illustration in the first place. We want to chill a trolly-wheel so that it may resist the grooving action of the rail for a long time. We could not possibly chill a thin wheel without weakening it very much; therefore it should be substantially proportioned *round the rim*. Properly, too, it should be a plated wheel. We have several times had occasion to refer to the internal stresses set up in cast iron through the irregular cooling of different parts, and in particular when treating of strap pulleys we mentioned

that the curved arm was adopted with the view of lessening the liability to fracture arising from that cause. For the same purpose when we chill wheels, we curve, not indeed the arms, for arms are not so suitable here, but the discoid centre (Fig. 458). The rim is chilled almost immediately that the fluid metal comes in contact with the cold iron ring, and consequently it has no further contractile power. But the centre



Figs. 458, 459, 460.

being yet red-hot, goes on contracting after the setting of the rim. In a small wheel the natural elasticity of the iron will prevent any evil effects arising from this source, but a large one must either inevitably break or be liable to fracture at any future time through internal tension and stress. By imparting a large amount of curve to the disc the wheel is safe,

provided, of course, that the metal in the boss is not in excess, and that the proper mixtures are assured. The disc will accommodate itself to molecular stresses, and lose some slight portion of its curvature.

First in order we take the pattern. There will be no difference between this and any ordinary pattern of the same class. Build up in segments as usual and turn to templet. Then follows the chill. It is seen in section in Fig. 458, and in plan in Fig. 459. It is made wide, and bonded, otherwise it is liable to burst. Six or eight inches of metal in the chill will not be too much for a wheel of two or three feet in diameter. It is accurately bored to the same shape as the wheel rim. As the rim alone needs chilling, the two faces of the castings are made with a sand mould. The bottom face will be strickled, the strickle working on the edge of the rim (Fig. 460). After having strickled the bed, the pattern will be laid upon it, and in the chill. Then the top box will be placed in position, and secured by its pins dropping into holes drilled in the top face of the chill, while the upper face of the pattern is rammed up. Or, instead of bedding in the sand floor, a bottom box can be used, and the pattern turned over. The mould, when cleaned and put together, will have the sectional appearance of Fig. 458. Fig. 459 shows it in plan. The rim will, if the founder makes his mixtures properly, be chilled as hard as highly-tempered steel to a depth of from $\frac{1}{4}$ inch to $\frac{3}{4}$ inch, as desired.

Suppose, however, that we have to make provision for chilling a roller for a turntable or for a crane, as shown in Fig. 461. It is quite clear that although the metal could be run into the chill, the casting could not be got out; therefore in this case we must part our chill. One way to part it would be through the centre in the plane of the wheel (Fig. 461, *a*, *a*), moulding in other respects as in the last instance. This would answer the purpose, and the only objection to it would be the "fin," as it is termed, or thin film of metal which forms at the joint. This could be ground off, however. Or the chill could be jointed in three in the line of the wheel axis, and fastened with cottars passing through lugs. Of the two, the latter is, perhaps, preferable, though a little more expensive to construct (Fig. 462).

Fig. 461.

Some castings are chilled through their inner diameters. A

wheel nave will illustrate how this may be done Common wheel naves, with tapered holes for tapered axles, are not bored; yet it is necessary that they should be smooth and truly circular, and durable beside. In order to effect these ends, a chill is often used in preference to a common core.

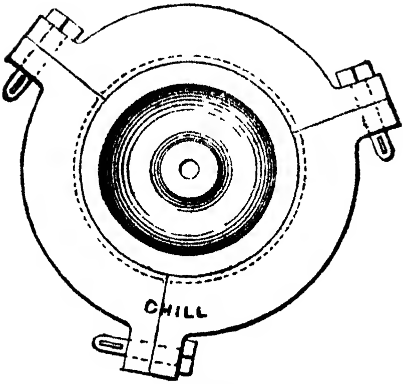


Fig 462.

Having the pattern presumably with its prints true, and the chill with ends corresponding exactly with the prints on the pattern, the one essential is that the chills shall always occupy precisely the recesses formed by the prints in the mould This could not be insured in prints formed in sand, because the weight of the iron chill would displace the more yielding sand to a certain extent. So iron rings, bosses, or clips, it matters not which, are cast and bored to fit alike around the pattern prints and the ends of the chill, and these being either rammed up in the sand, or fastened to the top and

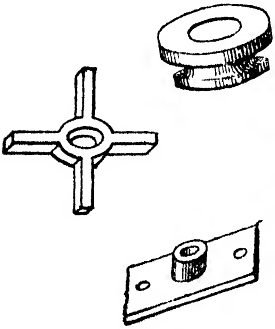


Fig. 463.

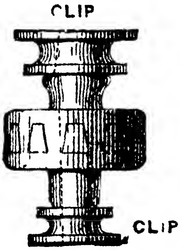


Fig. 464.

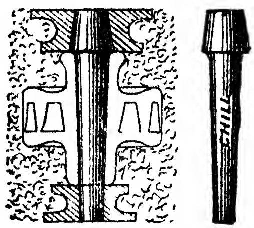


Fig. 465.

bottom respectively of the moulding box, retain the chill in place. Fig. 463 shows different forms of clips. Fig. 464 shows them attached to the pattern. Fig. 465 shows them round the chill.

CHAPTER XXV.

LOAM PATTERNS, &c.

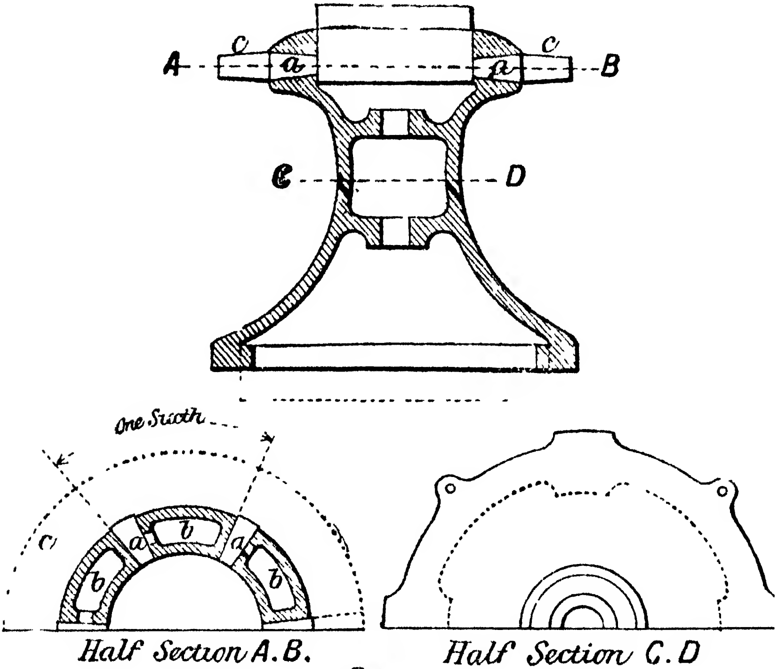
Why Used.—Methods of Making.—Capstan.—Bar Cores.—Boards.—Core-box.—Remarks on Wooden Patterns.

A LOAM pattern is quite a different thing from a loam mould. We made the boards for a loam mould in the case of the large cylinder in a previous chapter. We will now make the boards for a loam pattern, and that pattern shall be a common capstan. In cylindrical work a loam pattern is advisable when the mould is so small that a man could not conveniently work within it to strike the board round, and yet so large that a wood pattern becomes too expensive. This is usually, in fact, the ultimate consideration: the relative proportion the cost of the pattern bears to the value of the casting or castings. Thus, in the case of a capstan, if we had one or two castings only to make, we should use a loam pattern, but if we required a dozen or twenty castings all alike, we should consider a wood pattern the cheaper. Though its first cost would be considerable, the subsequent expense of the moulding would be diminished in a greater degree.

A loam pattern, then, is a pattern made in loam instead of in wood. Both are exactly alike in outline, the materials only of which they are constructed being different. A loam pattern, like a loam mould, is struck up, but the boards are cut the reverse to those intended for a loam mould. Brackets, however, facings, flanges, &c., not circular, are made as separate pieces, and attached to the loam body by means of nails. Where there is a longitudinal centre core, as in a pipe, a cylinder, or, say, in our capstan, it is customary to strike the core up first on the bar, to dry it, and give it a coat of blacking, and then to strike the body of the pattern over that. After the pattern is moulded the body thick-

ness is stripped off, and the core is placed in the mould for casting. Evidently this can be adopted only where one casting is required, and if this happens to turn out a "waster," the labour of striking up a pattern has to be gone through again. Therefore the question of striking up a pattern on another bar distinct from the core is an economical matter to be decided by the character and circumstances of each individual job.

Reverting to our capstan body, then (Fig. 466). We take the body, because that alone is made from a loam pattern,



Figs 466

omitting the base and cap (not shown) as being wood patterns of so simple a character as to call for no comment. Observe that there are six cores, *a*, *a*, required at the upper part of the capstan for the insertion of the lever bars. There are also lightening spaces, *b*, *b*, between these recesses (Section A, B). We can put in these cores in one of two ways. We might have six prints arranged equidistantly round the pattern, and left loosely set, so that they might be drawn singly into the

mould. But as it would be difficult to set them properly in loam, we consider it better to make a print continuous round the circumference, *c*, *c*, and to shape the cores in such a way that they will fill the print ring quite up, or "stop themselves off." Having thus decided, we simply make our boards as indicated in the sketches, Fig. 467 representing the board which strikes the core, Fig. 468 that which strikes the pattern. Stamp the

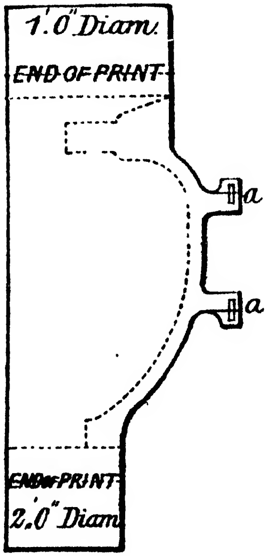


Fig. 467.

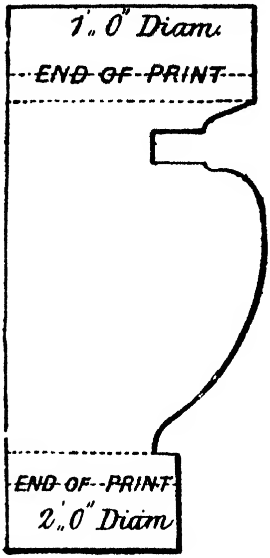


Fig 468.

diameters as shown, and mark ends of prints. The dotted line in Fig. 467 shows thickness of metal. Two little battens on the same figures, *a*, *a*, hold the bosses which carry the central spindle. When the core is struck up, of course these projecting bosses form recessed grooves or rings, and if the board were drawn back with these firmly attached to it a portion of the loam would be torn away also. But these are unscrewed after the core is made, the main board is drawn back, and then they are taken away parallel with the axial line. Fig. 469 shows the same enlarged. When the loam pattern is struck and finished, supposing the thickness of metal is struck on the core, it will in section have the appearance shown in Fig. 470.

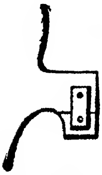


Fig. 469.

Then we take the core-box, and here we observe that a

plain tapered box, similar in shape to the holes required for the capstan bars, would be of no use. The sides of the circular print (tapered) and the sides of the holes are not in one plane, but inclined towards one another, and we ought to put this double taper in the core.

It sometimes happens that in a tapered core we can give the same taper to a print which we give to the core, and then the sides of the box are straight bevelled; but in this case such a method would prevent the pattern from moulding. Hence we shall cut the top and bottom edges of the box to the same angle as that to which the sides of the print and the

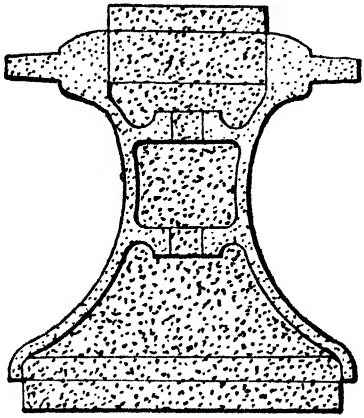


Fig. 470.

sides of the bar recesses are inclined towards one another (Fig. 471, elevation). This will, of course, necessitate the addition of a bottom board to the core-box, of the same shape as its edge. Further, the cores are intended to stop themselves off; therefore they must be so made that when all are put in place the ring print shall be completely filled up. This we shall accomplish by making the print portion of the core-box to fill up exactly a sixth of the ring print. Then, again, we have cores between the bar sockets, to lighten the casting and to insure regular contraction. The gas must be brought away from these cores; so to insure a communication with the outer air we will make the lightening cores unite with the bar cores by the round holes indicated in section, Fig. 466. Therefore one core-box will fill up print, take out bar and

lightening cores in one, and all the air will be drawn away at once into the print.

We may note by the way that although we have selected this capstan as an illustration of a loam pattern, it is, where the quantity is sufficient to pay for it, made in wood—moulding in the same fashion, with prints at each end, and a central core struck up on a revolving bar against a board. When, however, capstans are made in large numbers, it is better to have the patterns to leave their own cores. The capstan then would mould upright exactly as it stands when in position, and its pattern would have two or more horizontal joints, depending on circumstances; one at the centre, where the diameter is

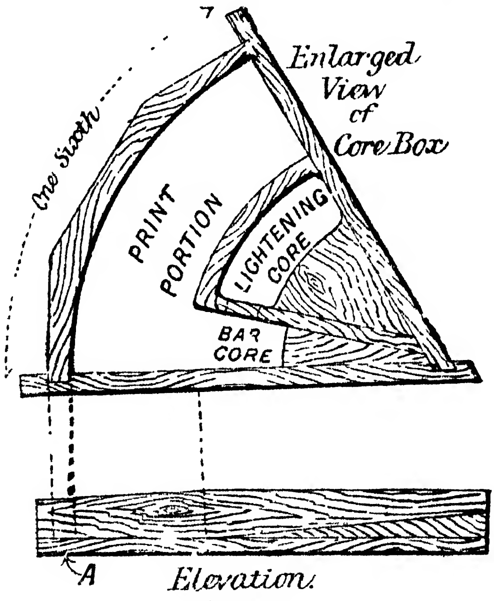


Fig. 471.

smallest—just where the line C D cuts in Fig. 466—and one at the top of the bar cores. The bar cores may be set in prints, or be made to rest upon small oval cores lying upon the central core. The various portions of the pattern will be built up in segments and turned to templet, good glued joints and pegging being essential. The loose joints, where the pattern parts, are either dowelled or turned with shoulders, to drop into one another. The tapering shape of the capstan affords every facility for this way of moulding.

CHAPTER XXVI.

MACHINE-MOULDED WHEELS.

The Passing of the Gear Moulding Machine.—Parts Necessary for Machine Use.—The Teeth.—How Moulded.—H-shaped Arm Cores. —Form of Core-box.—The Use of Striking Boards.—Advantages of their Use.—Various Types, with Illustrations.—Bevel-wheels. —Striking Boards.—Top.—Bottom.—Arm Core-box.—Disc or Plate Wheels.—The Tooth Block.—Making.—Teeth, Methods of Fitting. —Various Striking Boards, with Illustrations.—Tooth Blocks for Worm Wheels.—For Spiral Wheels.—Helical Wheels.—Their Purpose.—Conditions of Accuracy.—Block for Helical Spur.—Methods of Division.—How Made.—Obtaining the Screw Forms. —Block for Helical Bevel.—Methods of Division.—How Made.— Tooth Curves.—How Obtained and Worked.

Gear moulding machines almost completely drove the elaborate and costly gear-wheel pattern out of the foundry. Now the modern gear cutting machine, equipped with cutters made from high-speed steel is avenging the pattern.

The gear moulding machine is not in extensive use, and, due to the accurate and more reliable results that follow the use of gears having teeth cut from the solid, its use in the future will be even more limited.

With the passing of the gear cast from the pattern a highly skilled phase of pattern-making was lost, and these clever pieces of work are now very seldom seen.

Briefly described, the gear moulding machine is a device having a rotating arm capable of adjustment to any radius within certain limits, and at the extremity of which is held a wooden block having a profile which is a duplicate of the teeth to be cut.

The machine is provided with an indexing mechanism so that as the arm is rotated the teeth are spaced off in the sand, which is rammed up at each movement.

The heavier type of machine works direct on the foundry floor, accommodating wheels in the neighbourhood of 15 feet, while the lighter types are of the pedestal or bench variety.

The work which devolves upon the pattern-maker in their operation is as follows: For plain spur-wheels they are—block (Fig. 472), core-box (Fig. 473), diameter-strip, and finger-bit,

The block is made of a convenient length and width for the

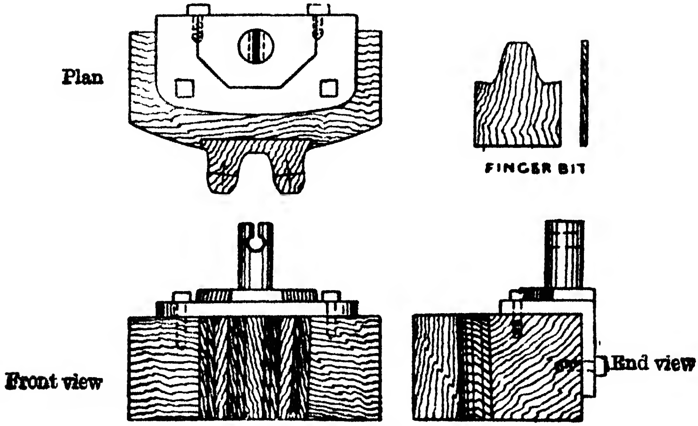


Fig 472.

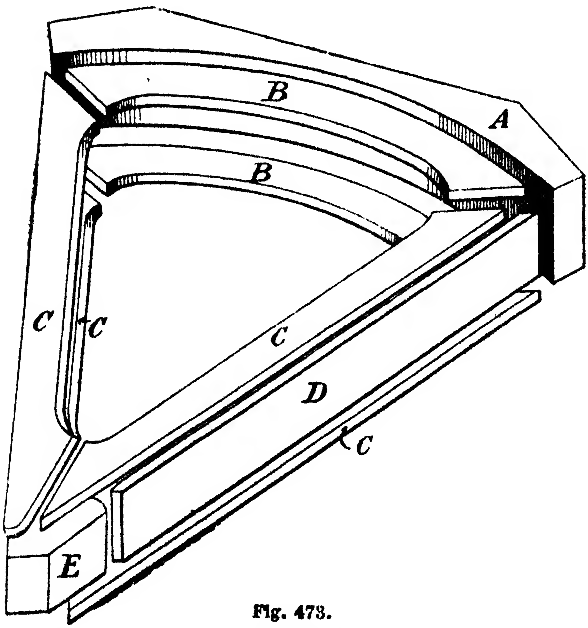


Fig. 473.

carrier of the machine, of the desired shape, size, and pitch (Fig. 472), and the moulding proceeds as follows ;—

The tooth-block is screwed to the carrier attached to the arm of the machine. Its distance from the centre of the machine—equal to the radius of the wheel—is given by a strip of wood, the diameter-strip, which reaches from the central pillar to some part of the tooth—either root or point. The proper change wheels being put on, the *space between* the two teeth is rammed up with sand, and the block is then lifted out of the mould by means of the hand-wheel actuating the vertical arm to which the carrier is attached. The sand is prevented from coming up with the block by a thin piece of wood—finger or hold-down bit—cut out to the same shape as the space between the teeth, and kept pressed on the included sand during the process of withdrawal of the block. When the block is clear of the sand, the requisite number of turns is given to the slewing-handle to carry it round a distance equal to the pitch, when the process of ramming up and withdrawal is again repeated. In order that the tooth block when in the act of being lowered shall not scrape away the sand already rammed to shape, the outer flanks of the teeth are reduced below the correct size. This, of course, is not detrimental to the form of the moulded teeth, the space alone *between* those on the block being used by the moulder. Each time the block is moved another tooth interval is rammed up, until the ring is complete. If the block is properly made, and the sand rammed sufficiently hard, and sprigged, the mould will not tear up at all, notwithstanding that the teeth are without taper, but will be ready for blacking at once.

The arms of machine-moulded wheels are made with cores, for which a special box will be necessary. They are usually H-shaped in cross section. To make the core-box (Fig. 473), in which the parts are represented as drawn slightly apart for the sake of clearness of illustration, the pieces necessary are a sweep, A, representing the inner portion of the rim, and as long as the space included between two contiguous arms—a fourth, sixth, or eighth part of a circle as the case may be; two sweeps fitting within this, B, B, one top, the other bottom, which are the ribs or flanges strengthening the rim; four half-width arms, C, C, fitting with the ribs and with each other; two half cross ribs, D, and a boss piece, E. These pieces are all rammed up loosely, that is, the parts are merely abutted, not screwed together, and taken from the sand one by one. They are rammed in an outer frame—not shown—consisting of two pieces screwed at the requisite angles, and of the same depth as the wheel. If there are four arms, the core-box will

be made at the angle of 90°; if six, of 60°; if eight, of 45° Sometimes an outer frame of iron is used as a permanent core-box for any sized wheel. Where that is the case the loose pieces only will be wanted.

These cores, either green or dried, usually green, are placed in position in the space included by the ring of teeth; a centre core for the wheel shaft is then fixed by measurement, completing the mould for a plain wheel.

But there are comparatively few wheels in which the moulding is quite so simple as this. Many wheels comprise some special details in the way of bosses, shroudings, arms, and so forth: but as the principles involved have been covered in the earlier pages, there is no need to go in to full detail.

In nearly all such cases the use of striking boards and core

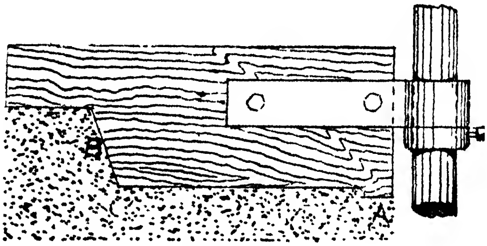


Fig. 474.

boxes is involved. Also when a board is used it is generally made to strike off the precise depth of the mould, equivalent to the width of face of the wheel. Also the board for the cope may be made to strike the cope face direct in loam, as in a loam mould; or it may be made to strike a reverse greensand bed upon which a greensand cope will be rammed. In some cases also the central arm cores will be set in the mould by measurement; in others they will be set in a print impression.

Thus in a perfectly plain spur wheel no striking board at all is necessary; but in many cases a striking board or boards are quite essential. Even, however, in the case of a plain spur a board is often used like that in Fig. 474. The chief advanage of using such a board is that it strikes off the joint face of the mould and gives the correct depth of the face of the wheel. Even if such a board is not used a level bed must be struck in any case, with a plain strip fastened to the machine

bar. Also when there is a boss A on the lower face, as there is in most cases, that can be struck by the board, so saving the trouble of bedding in a pattern boss. The reason why the front edge B of the board is cut sloping, is to prevent the sand from tumbling down, which would occur if the edge were cut vertically The bottom of the sloping edge will coincide with the points of the wheel teeth. There will therefore be a clear space above right away to the top, between the

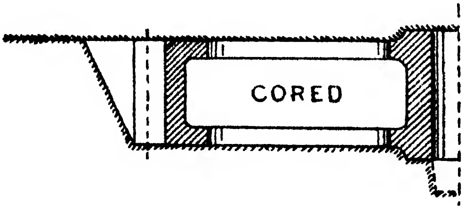


Fig 475

tooth points and the sloping wall of sand struck by the board, which will be filled up along with the tooth spaces in ramming. This, in my opinion, makes a better job than when the edge of the board is cut vertically, exactly coincident with the points of the teeth, as is frequently done. When there is a boss in the top, that also may be struck with a board, or a pattern boss may be measured in. Fig. 475 illustrates

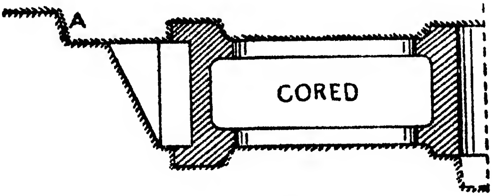


Fig 476

the wheel casting in half section, the edges of the striking boards being indicated by the fine shading.

Though I cannot here give detailed descriptions and illustrations of the various striking boards and core boxes that would be used in various types of wheels, the following views will enable a pattern-maker to gain a good idea of the ways in which these are made.

Fig. 476 represents a half-shrouded wheel. The shading shows the profiles of the edges of the bottom and the top

boards, the distinction between the two boards being indicated by the difference in the direction of the shading. In this and in the subsequent illustrations the edge of the top board may be cut to strike a cope direct, as in loam, or it may be cut to form a reverse mould upon which the cope will be rammed in place, the surface of the reverse mould being strewn with parting sand to permit of the clean separation of the cope from it. In the figure the cope is struck direct, with a check, as in loam work, seen at A.

During the ramming of the teeth it is necessary to fill up the bottom shroud space with a swept piece, otherwise the overlying sand would fall down and fill that up. The sweep is a short length of a few inches, and is withdrawn from time to time as the ramming of the ring of teeth proceeds

The next figure (Fig. 477) represents a wheel having T-

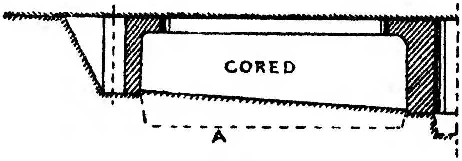


Fig. 477.

shaped arms. This class of wheel is not often made by machine, those with arms of H section being more easily made with cores. To make a wheel with T-shaped arms, the boards may be cut as indicated by the fine shading in Fig. 477. The bottom bed there is made to slope coincidently with the edges of the vertical arms. Made in this way, the cores do not abut, and the edges of the vertical arms will come out flat, not convex. If they are required convex, then the bed must be struck an inch or two below their edges, A, and the cores must be made to abut down the centres of the vertical arms.

Fig. 478 illustrates a pinion having a solid web instead of arms. The fine shading shows the shapes of the top and bottom boards. The faces of the plated portions, the inner part of the rim, and those portions of the bosses which lie within the faces of the rim are formed with annular cores, made from a core-box.

Fig. 479 shows a mortise-wheel. The boards might be cut as shown by the shaded lines, or they might be cut to

follow the lines of the edges A of the vertical arms, or to the dotted lines B. In either case corresponding outlines must be given to the top and bottom faces of the cores. The flat arms in this wheel are in a central position, because they interfere less with the driving in and pinning of the cogs than arms of H section would do. Both flat and vertical arms may be included in a single segmental core-box, the vertical joints of the cores coinciding with the centre lines of the arms. So that on each side of the box, half the width of a flat arm, and half the thickness of a vertical arm, will be screwed.

With bevel-wheels the process is not exactly the same as with spurs. Here striking-boards are always necessary. They are two in number—one for striking out the bed for the arms and the points of the teeth, the other for the top portions of the wheel. The boards are screwed to the bar shown

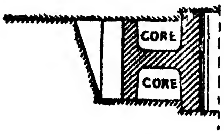


Fig. 478.

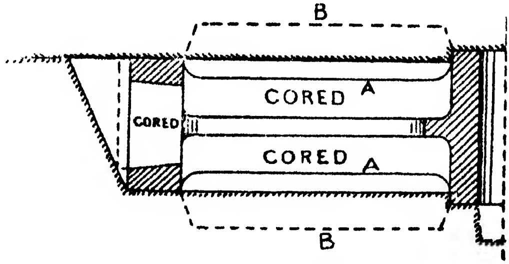


Fig. 479

in the figures, which fits over and turns round the central post. The striking edges are chamfered similarly to those of a loam board.

The moulder proceeds as follows with the top board, which being for greensand, as is commonly the case, is often cut the reverse way to one intended for a loam mould, as shown in sketch (Fig. 480). He strikes over a bed of hard rammed sand representing the top of the boss, the edges of the vertical arms A, and of the rim, and the outer or larger faces of the teeth, finishing off in a horizontal direction B, at their points to form the joint of the mould. A moulding-box or flask large enough to cover the bed thus struck, is set in position and rammed up on it—a layer of parting sand alone intervening. This is the top of the wheel mould, which is now removed. The sand in the temporary bed is now dug

away for the purpose of striking the lower part of the mould. The bottom board (Fig. 481) is set in position by means of the horizontal joint of sand already made C, and strikes the flat faces of the arms A, the inner edge of the rim, the smaller faces of the teeth, and their points B, with boss D. The

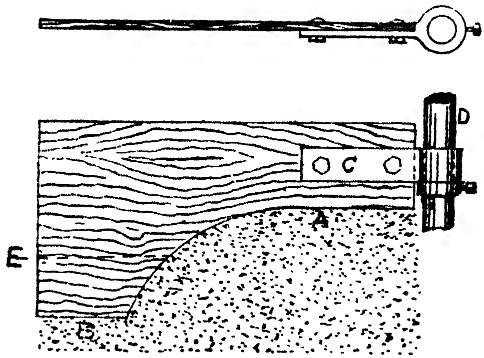


Fig. 480.

tooth block is then screwed on the carrier of the machine, and the moulding proceeds as in a spur-wheel, with the exception that no finger bit is required. The arm-cores are also made and set in the mould in a similar way. For bevel-wheels, however, the arms are of the same shape as those in an ordinary pattern, so that the remarks we have made about

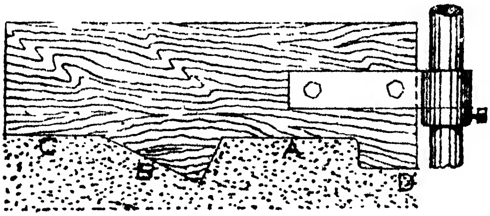


Fig 481.

H arms will not apply here. The outer sweep of the core-box represents the inner side of the rim, and the way to make it can be seen by a glance at the sketch (Fig. 482), where the rectangular figure represents the rough block from which the bevelled inner portion of the rim, shown shaded, is cut. The tops of the cores, being curved, must be worked off by

means of a strickle, similar in shape to the top board (Fig. 180). So that we require sweep (Fig. 483), two half arms, two half ribs, A A—that is, each rib is of half the casting thickness—boss, loose for withdrawal as before, strickle, and guide B for the strickle.

The tooth blocks of bevel-wheels, consisting only of a short

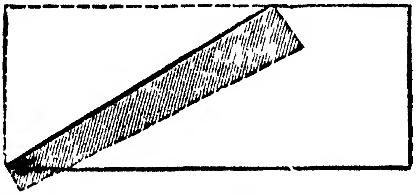


Fig. 482.

segment and therefore lying without the range of lathe work, have to be cut to shape by a method of intersecting planes.

Looking at the section of a bevel-wheel rim in Fig. 484, the working faces of the tooth block must correspond with the faces *a*, *b*, *c*, in the figure. The interior of the rim, and the

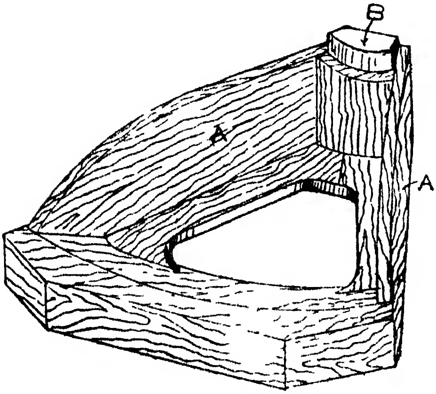


Fig 483.

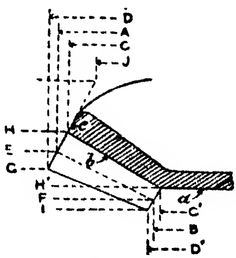


Fig 484.

top faces of the arms, being formed with cores, have no corresponding parts in the tooth block. By comparing the tooth block (Fig. 485), with the section of the rim (Fig. 484) it will be seen that there are certain vertical and horizontal lines similarly lettered. If these lines in the first figure are reproduced accurately on the second figure, and the block worked

thereby, then it is evident that the latter figure will have identically the same sectional form as the first figure. The way to make the block is to prepare that portion which forms the backing for the teeth first, and fit the teeth on after-

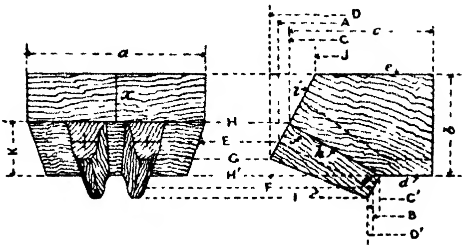


Fig. 485.

wards. The backing itself is shown outlined in Fig. 486. It is first squared to the cubical dimensions *a*, *b*, *c*, to suit the size of the wheel and the carrier of the machine. The dimensions *b* and *c* are, however, arbitrary within the limits of an inch or so. The centre line *x* is struck upon the block, and the extreme sweep C—compare with C, Fig. 484—is struck on opposite faces of the block, and worked through. The sweeps J and C′ also are struck, corresponding with J and C′ in Fig. 484. When the sweep C has been worked through, the line H is gauged round the swept face, corresponding with the line H in Fig. 484, at a definite distance, K, above the face *a*, which face corresponds with the face *a* in Fig. 484. Then the two bevelled faces, *h* and *i*, corresponding with *b* and *c* in Fig. 484, are worked across from C to H, and from H to J.

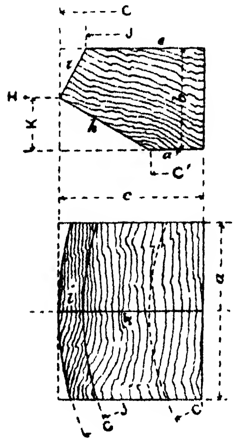


Fig. 486.

In reference to the intersection of the line J with the top face, *e*, of the block at the distance *b* from the bottom face *a*, that, of course, has no existence in the casting. The point of intersection is one obtained on the drawing (see previous figure) only as a convenient method of getting the correct bevel of the face *i*.

The backing block is now ready for the teeth, which are fitted round it as a rough block and marked in place. The latter block should be held temporarily with screws, while the lengths for the ends of the teeth are scribed from the faces of the backing block. The tooth block had better be removed by the withdrawal of the screws, for the working of the ends of the teeth to correct curves and bevels. It will then be replaced, the pitch-lines and point-lines struck with trammels, the tooth shapes marked out, and the teeth worked either away from the main block with planes, or on the block with gouge and chisel.

In reference to the methods of fitting the teeth on their backings, there are two or three matters to be borne in mind. The grain must be arranged for strength, which is secured by making it run longitudinally. There is then no rough end grain to tear up the sand, but only smooth surfaces—plank way. Also

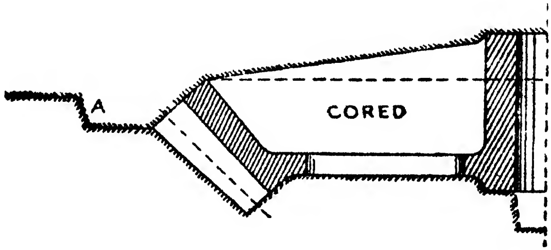


Fig. 487.

as hollows or radii are usually worked in the roots of the teeth, the longitudinal direction of the grain is favourable to working these. Often also, instead of merely fitting the teeth around the backing, I have let them in with a dovetail (see Fig. 472, p. 280, by which arrangement the thin edges of the hollows are prevented from curling up, as they would do if the glue became moistened in the damp sand. In some cases I have seen the teeth and their backing worked in a single piece, the grain running perpendicularly, or with the teeth throughout.

As I did just now in spurs, so now I will briefly indicate the methods of making bevel wheels of various types by machine. Fig. 487 is an ordinary bevel made, as in loam, with a checked joint.

Fig. 488 is a bevel half shrouded. The bottom part of the mould terminates at the plane A, continuous with the teeth points on the major diameter. The top part terminates on the

plane B, coincident with the outermost edge of the half shroud. The space between A and B is filled up with segmental cores of thickness C, having the cross-section indicated by the shading. Note that the front edge of the board is cut to the same bevel as the points of the teeth, and not, as in the case of

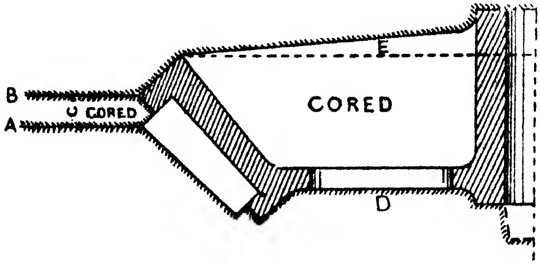


Fig. 488.

a spur-wheel, to slope off at a little distance away therefrom. Of course, in a bevel the necessity for this sloping off does not exist. The mould in this case is not checked, but the cope is rammed on a reverse bed. The arms of the wheel are formed with segmental cores, their bottom faces resting on

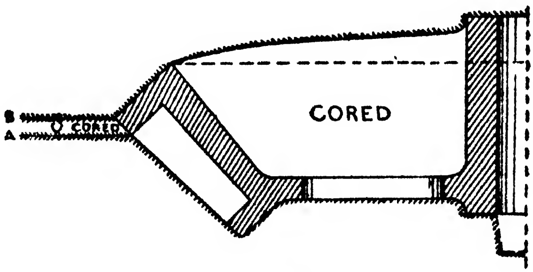


Fig. 489.

the face D, and their top sloping faces, E, meeting the cope similarly sloped.

Fig. 489 shows a bevel-wheel full shrouded to the points of the teeth. Here the bottom board strikes off to the plane A, and the top board to the plane B, and the thickness C is filled round with segmental cores. The arms are formed with cores, as in the last example.

Fig. 490 shows a plated wheel with checked mould, and the

shading indicates the profiles of the bottom and of the top boards The latter takes out the interior of the wheel and the whole of the boss.

Fig. 491 indicates the striking of a bevel mortice, the arms being formed in cores. The dotted lines at A indicate the prints for the mortice cores. The mould is checked also.

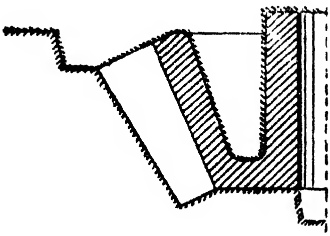


Fig. 490.

Worm-wheels are frequently moulded by machine. Fig. 492 shows the best form of tooth block. Note that the teeth C, with their block B, are divided from the backing A, and held temporarily during ramming with a dovetail *a*. The advantage of this arrangement is, as in the case of helicals (see p. 293), that the backing can be lifted vertically with the carrier of

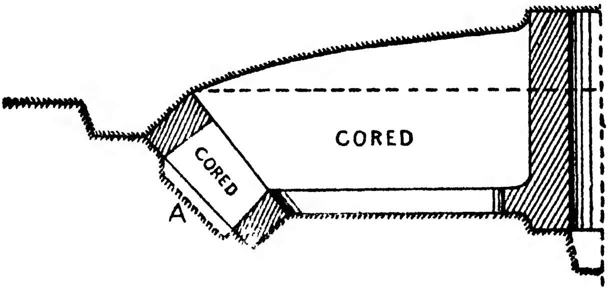


Fig. 491.

the machine, and the teeth afterwards withdrawn horizontally with the fingers. Without the division the entire block would have to be withdrawn horizontally, an awkward operation in the case of most machines. Of course, there is no necessity to divide the teeth through the horizontal central plane, as in the case of a sheave wheel (see Fig. 351, p. 218), the manner of withdrawal being different.

Toothed blocks are also made for twist-wheels. These, like worm-wheel blocks, have two teeth, made distinct from the backing and attached to it with sliding dovetails. But there is another joint in addition, one between the two teeth, as in the case of small helical pinions (see p. 294). This is necessitated by the undercutting of the outer flanks in relation to each other, due to their long twist embracing so much of the circumference of the wheel, and which, if the two teeth were drawn at once, would pull down the sand. Being drawn separately they do not pull down.

Helical wheels are mostly made by machine instead of from whole patterns. It is better to make them thus, even though it were not cheaper to do so, because greater accuracy is assured in machine-moulded than in pattern-moulded wheels, and inaccurate helical gears are more unsatisfactory than inaccurate spur gears.

The object in using helical wheels is to avoid the friction due to the sliding and rubbing of the surfaces of the teeth in contact, which unavoidably takes place in all cycloidal gears. In helical wheels formed on correct principles no sliding at all will occur, but rolling of surfaces only. It is because these wheels are often badly formed that they do not always yield the results expected of and claimed for them. To be accurate, each tooth must form a portion of a true screw of extremely long longitudinal or axial pitch. Yet this dimension is not considered at all in practice, the angle of the teeth being settled only with regard to the conditions of contact, that one pair of teeth shall not quit contact until the next pair are beginning contact. This will obviously be regulated by the diameters and the breadths of particular wheels. As regards pitch the circumferential pitch alone is considered; that is the pitch measured in the plane of rotation of the wheels, just as in ordinary gearing. Then again, in practice, wheels are almost invariably made of double helical type, each half-tooth forming a short section of a screw of long axial pitch, but of opposite hands. In this way the stresses upon the teeth are balanced on each side of the median line of the wheels, and there is no resultant end-long pressure on the shafts.

Since the teeth of a helical wheel are sections of screws, it follows that in any such wheel the teeth must possess some amount of helical twist. In wheels of large diameter and

little width this twist will be scarcely, or not at all, perceptible to the eye. In pinions of small diameter and considerable width it will be very obvious. The reason is that, in the first case, the length of the tooth bears an extremely small proportion to the total length of the entire screw of which it is a section; in the second case, the tooth length bears a much larger proportion to the total length of its screw. Such being the case, it is permissible in the extreme case of large wheels with narrow faces to make straight teeth, and fasten them on the rim diagonally, because the almost imperceptible twist due to the screw form is not so great as the inaccuracy inseparable from a moulded casting. But in no other case is it permissible to use straight teeth if the advantage due to the helical form of tooth is to be secured, but the teeth must be formed as portions of true screws.

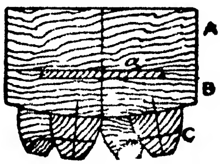


Fig. 492

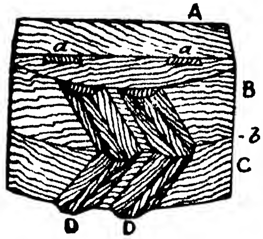


Fig. 493.

To impart this outline it is necessary to mark out and work the teeth in their proper positions on the tooth block. Also it is desirable in all cases, and necessary in others, to make certain joints in the tooth blocks for helical wheels which do not occur in the blocks for spur gearing. I will, therefore, now describe the method of construction of a helical spur, and also of a helical bevel, noting these points.

Fig. 493 illustrates a typical helical spur tooth block. It consists of three portions, the backing, A, to which the carrier of the wheel moulding machine is screwed; the body portion, B, C, the face of which is worked to the same curvature as the rim of the wheel; and the teeth, D, two in number, as in ordinary tooth blocks. The backing, A, is made separately from the other portions for this reason:—

Except where a special attachment is rigged up for the purpose, wheel machines lift the tooth blocks vertically. It

is obvious that a helical block cannot be lifted vertically because of the sloping of the teeth from the perpendicular. Hence the backing, A, is attached to the block by dovetailing, *a*, and is the only portion lifted vertically along with the carrier, leaving the teeth behind in the sand. These are then withdrawn backwards in the horizontal direction with the fingers of the moulder. The dovetail form of union is used because it is at the same time the most secure form of temporary attachment, and the most easily released.

Frequently, also, though not invariably, the teeth are divided along the middle plane, *b*, which corresponds with the apex of the teeth. This is done to facilitate the ramming of the teeth, the moulder being better able to use the pegging rammer in the lower halves of the teeth when the top halves are removed, than if the top halves were in place and interfering with the action of the rammer. This division is, however, of less importance in the case of large, shallow wheels with teeth of coarse pitch and flat angle than in the case of smaller, deep wheels with teeth of fine pitch.

Further, the blocks for small pinions have to be divided yet again between the teeth, the line of jointure following the angles of the teeth. This is necessary because of the undercutting which is present on the outer flanks of the teeth of such pinions, and which would render it impossible to withdraw the pair of teeth together without breaking down the mould. Forming a joint between the teeth, they can each be withdrawn separately without any injury to the mould.

If up-to-date pattern-making equipment is available, the production of any desired block becomes relatively simple, as a perusal of Chapter XXIX will demonstrate. Methods vary slightly in different shops, but the essential principles are illustrated in the figure, and that method is as good as any other. And even when not required for convenience of moulding, it is always desirable to joint the teeth and their backings along the median plane, *b*, in order to have faces there whereon to mark the tooth shapes, as we shall note presently.

Such a block as this is first prepared in the rough by dovetailing the front and back portions together, planing them while together to the correct parallel thickness—equal to the breadth of face of the wheel, and squaring the back face therewith. The centre line is then carried round with a square, and the sweep of the front face, corresponding with the rim of the wheel, struck and worked round. Upon this face a block is fitted for the teeth, the grain running in a

different direction from that of the backing, as indicated by the timber shading. This block is screwed on, the ends dressed off, and the centre line of the pitch struck over them. The shapes of the teeth are then marked upon the outer faces, and also upon the joint face obtained by dividing the blocks along the median line *b*, as just now noted. The forms of the teeth are similar to those used in ordinary gearing.

Now the question of screw-twist comes in, and how best to work it. Having the tooth shapes struck on three faces, it is usually good enough to work the positions intermediate with a templet fitting into, and of the same shape as, the tooth spaces. Before using the templet, the face corresponding with the tooth points is worked round, and the lines where the tooth faces meet the points are struck with a narrow thin strip of wood, or strip of steel, curved round the outer face, that is, of the tooth points, from the outer to the middle planes of the wheel. These lines become the guides to the templet, the shoulders of which also rest upon the outer face at the completion of the work. This is accurate enough for almost any job. The only thing is that, in a small pinion, the teeth of which will have very much twist, some inaccuracy is bound to result unless the templet is held and tried quite correctly during working. Hence there is an advantage in such cases in unscrewing the teeth, and marking the twist from outer to middle faces upon the backs or roots of the teeth, as well as upon the points. The root lines can then be set in a little way with the chisel, and the teeth re-screwed in place, when the lines thus set in will become a guide to the correct testing by the templet at the bottom of the teeth.

The working of the tooth block for a helical bevel is more troublesome, and, as with the spur blocks, methods are modified in different shops, and under different conditions of bevel, breadth, and pitch. Many flat bevels are quite unjointed, lifting vertically. Many are unjointed because some machines are provided with an appliance for lifting them away from the mould at any required angle; some are drawn back horizontally. But I will illustrate a typical class of block (Fig. 494), and the best and most conveniently made in my opinion, which can be withdrawn in any machine without any special appliance, by the same method as the spur block; that is, by withdrawing the backing vertically along with the carrier, and the teeth horizontally with the fingers. Made thus, too, it is more readily struck out than as if made solid.

for the same reasons given in connection with the spur toothed block (Fig. 493).

The bevel tooth block (Fig. 494) consists of backing, A, body, B, C, in two portions jointed from the centre of the teeth at the root, and the teeth, D, also in two portions A, B, and C are dovetailed to one another as in the case of the spur-wheel. These parts have to be prepared very carefully to dimensions, based on the intersections of certain vertical and horizontal dimensions taken from the full-sized sectional drawing of the wheel, precisely as in the case of a common bevel wheel; com-

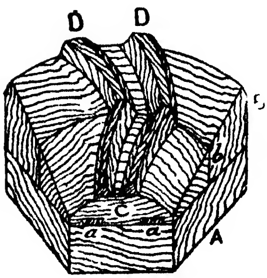


Fig 494.

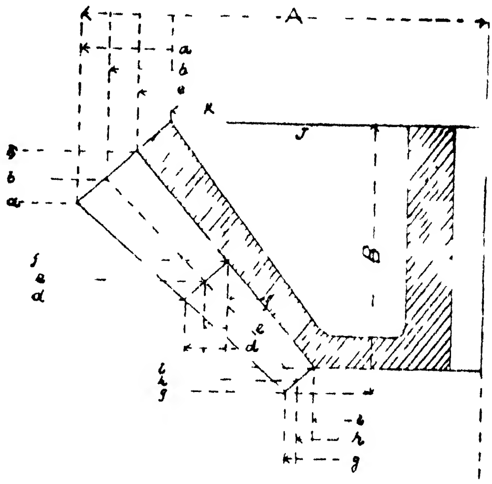


Fig. 495.

pare Figs. 484, 485, 486, pp. 287 and 288. In the sectional view of the wheel rim and teeth (Fig. 495) the horizontal and the vertical lines, variously lettered there, correspond with the pitch-lines, points, and roots of the teeth upon the major, minor, and middle diameters. These dimensions are transferred to the helical tooth block already prepared with dovetails, and squared up, and having centre lines marked on. Horizontal lines will be marked with long toothed gauge from one of the faces of the block, and the vertical or sweeped lines will be struck with trammels. The illustrations will render this clear, I think, without going into the tedious and minute details of the striking of each individual line. So far there is no difference except in the jointings, in

the preparation of the backing for a common bevel and the backing for a helical bevel.

But the longitudinal twist of the teeth, due to the screw formation of the wheel, demands some notice. They are not quite so simple of construction as the teeth of helical spurs. The development of a helix on a cone, which is the basis of the tooth forms on helical bevels, results in forms different from those in the development of a helix on a cylinder, which is the basis of helical spurs. Thus the tooth of a helical bevel will have the double form seen in Fig. 494 obtained by dividing the pitch and the width into an equal number of parts, and drawing the curves through the intersecting points. Only by this method can constant contact between pairs of teeth be assured. From this also it will be seen how abominably bad must so-called helical bevels work when straight teeth are put on diagonally.

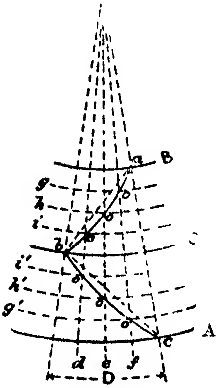


Fig. 496.

Let Fig. 496 represent a small segment of the rim of a helical bevel wheel; let A be the outer, B the inner diameters, and C the middle plane, corresponding with the apices of the teeth, and D the extreme positions of the centre line of a tooth. Now, if the teeth were simply straight teeth set at a bevel, in the manner indicated by the dotted lines, *a*—*b*, *b*—*c*, which is a frequent practice, it would be impossible for them to gear properly, as the following construction will show.

Divide D into any number of equal parts, *d*, *e*, *f*, and A—C, C—B likewise into the same number of equal parts, *g*, *h*, *i*, *i′*, *h′*, *g′*. A moment's consideration will show that the points of contact of the helical teeth in mutual gear must pass successively through the points of intersection of these divisions. Then, and then only, will the teeth be in mutual contact at equal distances on each side of the middle plane C. If their contact took place along the straight lines *a*—*b*, *b*—*c*, neither half of the teeth would be in contact at the same time equidistantly from C, and the gear would, therefore, not only be bad, but the resulting pressure would be of an end-long character. Only at the points *a* and *c* could the pressures be exercised equidistantly from C at the same time. This figure, therefore, shows how, in practice, the curves of helical bevels should be obtained, and also the reason why

the curves should be in opposite directions on opposite sides of the middle plane, c.

The helical curves ought to be marked out by means of intersecting lines on the drawing-board for point, pitch-line, and root, since they vary on each plane. In the case of large wheels the variation would be almost inappreciable, but in small pinions the curves would vary very much on the three planes.

The shapes of the teeth will be marked out upon the major, minor, and middle diameters. Then the portions intermediate will be worked carefully with gouge and chisel, the eye chiefly judging of their accuracy. Templets may be made for intermediate sections, as one, for instance, midway between each face and the middle plane, or two, if the width of face is considerable. But the accurate forms of the portions intermediate between these will still have to be estimated by the eye, because the shapes alter in every section. In the case of some small pinions of wide face it is better to adopt the plan mentioned in connection with helical spurs, that is, to unscrew the teeth and mark their curves upon the back or root plane, then set these curves in with the chisel, and screw the teeth back upon the block. In this way we can obtain correct curves upon root as well as point, which will be of material assistance in subsequent working. Yet another division may be made, one around the pitch plane, and the curves on the pitch plane may be marked on that. These divisions do not involve so much extra work as they may seem to do, for most of the extra time spent in jointing is saved in the increased facility in working out, because the wood can be cut away at once with confidence to these lines scribed on the different faces and ends, which is better than tentative and doubtful working by the eye chiefly. After the several sections are worked, the joints on the several planes can be finally glued and screwed.

A large amount of skill and time required in setting out the teeth for gear patterns has been saved by the introduction of such machines as seen on pp. 247 and 336. For helical gears the machine has a dividing head geared to the lead screw of the table traverse and thus follows standard engineering practice. Suitable gears for varying the pitch are also available.

CHAPTER XXVII.

PATTERNS FOR PLATE MOULDING.

Turn-over Boards.—Various Types.—Plate Moulding.—Odd Side.—Wooden Plates.—Metal Plates.—Details of Fitting same.—Casting Plates.—Economies of Plating.—Examples.—Moulding Machines.

The basis of plate moulding is seen in the turn-over boards, which are also called bottom boards and joint boards. Their purpose is to assist the moulder either by economising his time, which would otherwise be wasted in levelling or jointing, or by rendering temporary support to a pattern which, but for that aid, would yield excessively to the rammer. In the former case the board has a plain surface; in the latter it

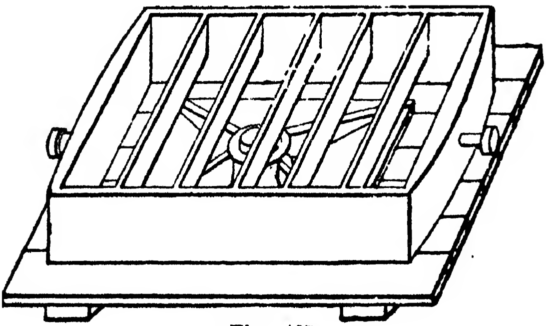


Fig. 497.

follows the outline of the pattern, or moulder's joint, whatever that may chance to be. When the board is plain and the pattern in halves, the bottom half of the moulding box is laid upon the joint board, inclosing one half the pattern, which also has its joint upon the joint board, and is there rammed up (Fig. 497). Both

joint and pattern are therefore true without the trouble of levelling with winding strips. The box then removed from the board and turned joint upwards, receives its top part and the other portion of the pattern for the completion of the ramming up.

A board of this kind should be made stout, of from 1½-inch to 3-inch stuff, according to size of work. Pitch-pine or red deal are better than yellow pine, because harder. The pieces of which it is composed should be narrow and open-jointed,

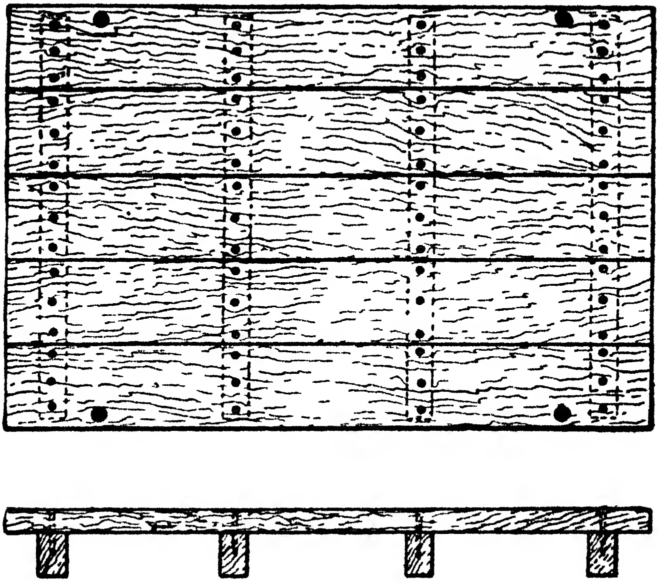


Fig 498

to allow for the swelling and expansion in width which will take place in damp sand. They will be held in place with stout battens screwed underneath, 4 inches to 6 inches deep, by 2 inches or 3 inches thick.

Fig. 498 shows such a board with the holes for the pins of the moulding box; Fig. 499 is another, used when the presence of battens would be objectionable, as when pattern parts are put on both sides. This board is made of two thicknesses of strips slightly open-jointed, crossing at an angle, and secured with wire nails. Strips of hoop iron are rebated into

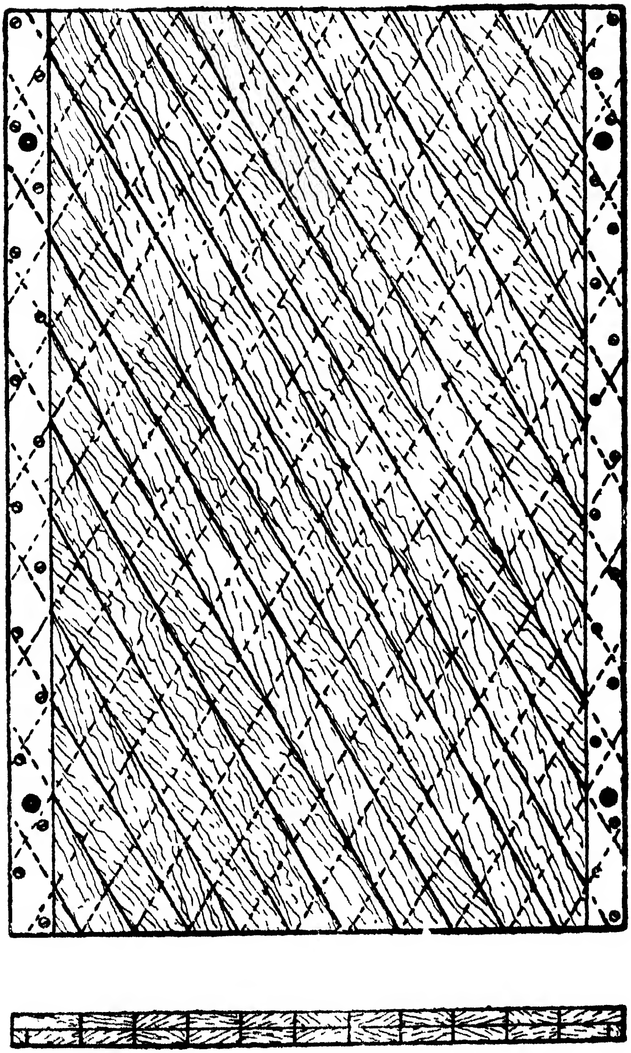


Fig. 499

both faces next the edges and screwed on, serving to retain the strips at the edges, and to receive the holes for the pins of the moulding box. Such boards are made of large dimensions, both oblong and square.

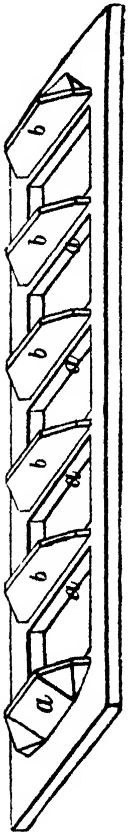


Fig 500.

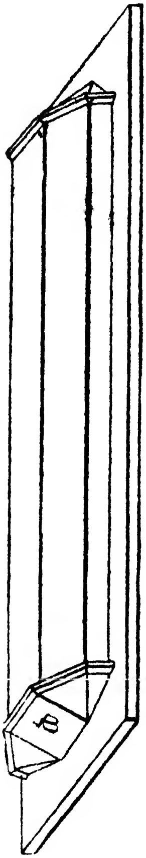


Fig. 501.

The turn-over board for the pattern of a gutter casting (Fig. 500) will afford an excellent illustration of that type which is framed to give temporary support to patterns too slight in themselves to retain their proper shape in the sand.

The bottom board in this case answers three useful purposes. Gutter castings are very thin, not more than $\frac{1}{4}$ inch, oftener $\frac{3}{16}$ inch, so we stay our otherwise weak pattern upon its blocking. Then, in consequence of their shape, they invariably curve in cooling, and we counteract this by imparting the amount which experience tells us they will curve, to the bottom board, but of course in the reverse way. Also we make the moulder's joint (Figs. 500, **501**, *a*, *a*) at the gutter ends, and so save him the trouble of sleeking it every time he rams up the pattern. But for these precautions, the gutter ends; the flanges, or sockets and spigots, as the case may be, would be awry, and not match one another; and the castings would be hollow on the back, so that the water would always find a low place to lie in instead of running right away. In a gutter of the annexed section the open side must be made *hollow* in the pattern to bring the casting straight. In a 6-feet or 7-feet length the amount of concavity will range between $\frac{1}{4}$ inch and $\frac{3}{8}$ inch, variable according to its depth; so we round the face of the bottom board by that amount, and the sketch (Fig 500) shows how it is best made.

First there is a stout frame of, say, 3-inch stuff, mortised and tenoned, or else jointed with half lap joints. It must be both wide and long enough to leave a margin of sand beyond the sides and ends of the gutter, and to take in the moulding-box lugs besides, for the reception of whose pins holes are bored with a centre-bit. Blocks of stout wood are screwed on the cross ribs of the frame (Fig. 500, *b. b*) at intervals of 10 inches or 1 foot—of exactly the same shape as the inner cross section of the gutter. These being parallel and fastened on a curved surface, will partake of the gutter curve. At this stage the pattern is made, the thin strips which form its sides and bottom being glued edge to edge and bradded while in place—flanges (Fig. 501) or sockets and spigots being added at discretion. Then, for the convenience of the moulder,

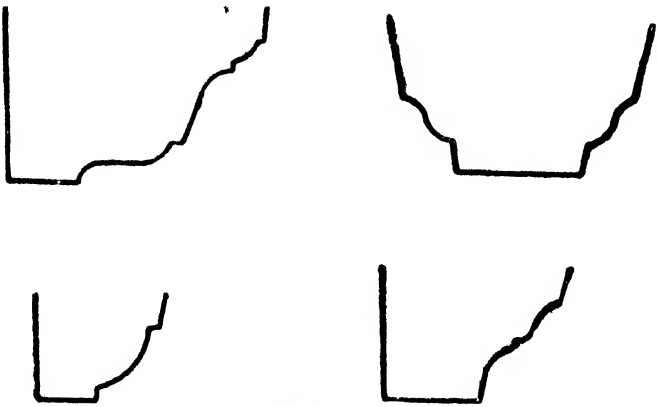


Fig. 502.

we screw the chamfered blocks at each end of the board, *a*, *a*, to form his joint. All is ready now; the pattern being laid upon the board, and the bottom box dropped over, the sand is rammed around, and forms the reverse of the outside of the gutter, with its terminal chamfered joints, and its longitudinal curved side ones also. The box with the gutter *in situ* is then lifted and turned over, the top part put on and rammed up. The box parts are afterwards separated and the pattern drawn. Thus both rapidity and accuracy are secured, which would have been impossible of attainment with an unsupported wood pattern.

The section in Figs. 500, 501 is plain. Common sections are also shown in the group of Figs. 502. Patterns like

these are almost of necessity made of metal, unless but a few castings are required. The thickness is only from $\frac{3}{16}$ inch to $\frac{1}{4}$ inch, and though the patterns can be built in wood upon the bottom board they are easily rammed out of truth in the spaces between the distance blocks *b b* in Fig. 500, while patterns of metal—properly of brass—will not yield under the rammer. The moulds for such patterns can be strickled up, or they are cast from rough wooden ones, double shrinkage being allowed in each case. The various strips of which a wooden pattern is built are glued and bradded along the

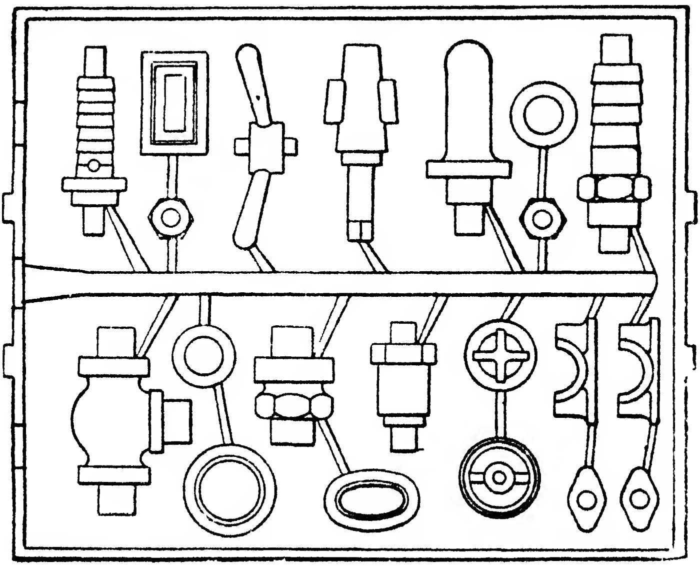


Fig. 503.

edges. Curved sections are formed by steaming them and bending.

In plate moulding a still further economy is obtained, since the founder has not even to turn his mould over. The boxes are not, in fact, brought together until the mould is finished; neither are the runners cut by hand, since they form part of the pattern on the plates. Plate moulding is a system of a very elastic character. Some plates will have flat faces, others will have those of irregular outline, corresponding with the varied classes of joints required for different kinds of patterns and castings. Others will receive patterns on one face only,

corresponding with that class of work that only requires a plain top; but many more will carry pattern parts on opposite faces; the patterns being either in halves or divided in unequal proportions. And instead of putting these portions on opposite sides of one plate they may be and are often put on one side only of two plates.

The methods of odd-side moulding will help us to understand the mounting of patterns on plates with uneven joints, and odd side also is often a preliminary stage in the making of such plates, an explanation of which will be given later, p. 314. The work of odd-side moulding is a half-way device to plate moulding. In this system patterns are selected of sizes

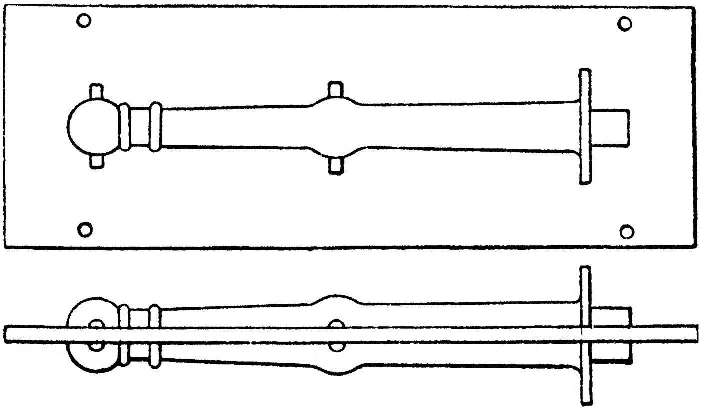


Fig. 504.

suitable for filling a box, and embedded in an odd-side, see Fig. 503, which shows the odd-side with the patterns in place, and the runners also. This corresponds with that form of jointboard which is recessed to receive numerous small patterns. In the odd-side either hard-rammed sand, or a plaster mould, or a mixture of sand with other ingredients forms the matrix in which the patterns are embedded, taking the place of the recessed joint board The odd-side also corresponds exactly with the dummy mould in which a pattern or patterns are bedded to form the first ramming face in moulding by turning over. The odd-side never forms a portion of the actual mould, but it serves to ram the first part of each mould—the bottom part—upon; and upon this last the top part is afterwards rammed. The odd-side is not thrown

away until badly damaged by long service, but it saves the making of a first or false mould for all the moulds — sometimes hundreds,— that are commenced on it.

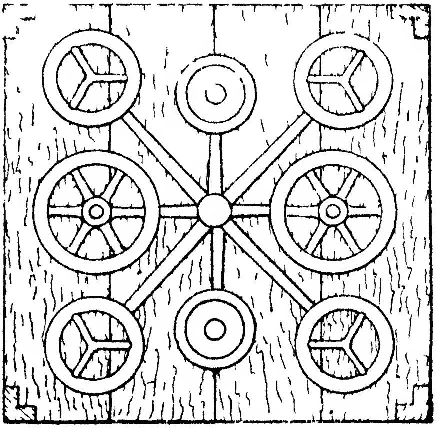


Fig 505.

When two odd-sides are used, there is a further economy, since two men can be working on the same mould, one ramming tops, the other bottoms, and the mould parts are not rammed together, or brought together at all until finished. The numerous analogies therefore between these methods, and plate- and machine-moulding are obvious.

The simplest plated mounting is that of patterns of wood on plates of wood, or in some cases metal patterns are mounted on wood. This is exactly like the fitting often done on bottom or joint boards with a view either (1) to retain a flimsy pattern in shape; or (2) to form an artificial joint, with or without runners, and so save the time of making these at each time of moulding. A pattern may then be contained wholly upon one side of one plate, or halves of a pattern may be carried on opposite sides of one plate, Fig. 504, or halves may be put on one side of two separate plates.

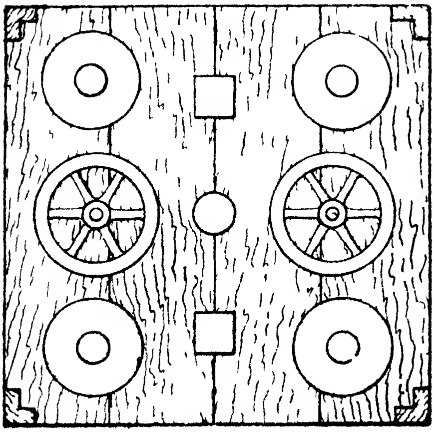


Fig 506.

Figs. 505, 506 illustrate the latter arrangement — wooden plates with common lift valves, clack-box covers, and hand-wheels upon them. Fig. 505 is the plate which forms the

bottom of the mould, and upon it the deeper portions of the patterns are fastened if comparatively shallow, dowelled if deep, and the runners to each radiate from the central feeder or gate. The **clips** screwed at the corners of the plate are there for the purpose of clipping the moulding box without allowing any slop movement sideways. The next plate, Fig **506**, has upon it the top portions of the patterns, corresponding in position with those upon the lower plate, a central stud-hole being bored to receive the runner pin, shown in plan. It also has clips for the maintenance of the box in position. The two corresponding halves of a well-fitting moulding box are rammed, one on one plate, the other on

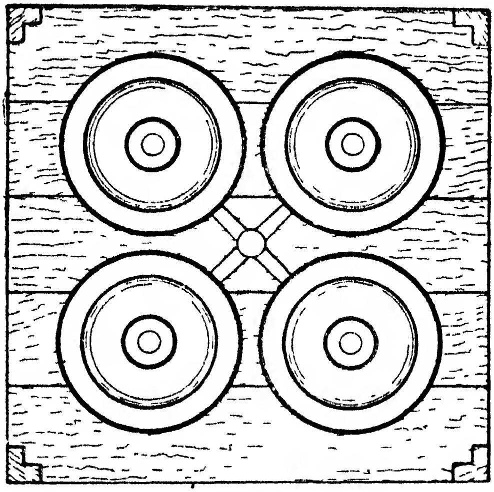


Fig 507

its fellow. Being then put together by their pins, they form the complete mould ready for the pouring of the metal.

Patterns are often placed wholly on one side of a plate of wood. Thus Fig. 507 illustrates four roll patterns of metal put on a wooden plate, the latter fitting the box also by means of corner pieces, a method which is capable of wide application. In the case of the smaller sizes, a dozen, or three or four dozen patterns may sometimes be put on a single plate. All these variations and devices exist in metal patterns on metal plates, as well as in those of wood.

Then, further, the joint faces of the boards, instead of being

in one level plane, often have to be of irregular contour to suit patterns which have irregular joint lines, present either in the pattern itself, or in the mould only, or in both. Patterns of this kind are sometimes made in wood and mounted on thick plates of wood which are cut out to form the irregularly shaped joints, this being a device the reverse of that shown in Figs. 500, 501, p. 302, where the joint faces *a*, *a*, are put on, and stand up from the board In many cases the two occur in combination, recessed portions and portions in relief.

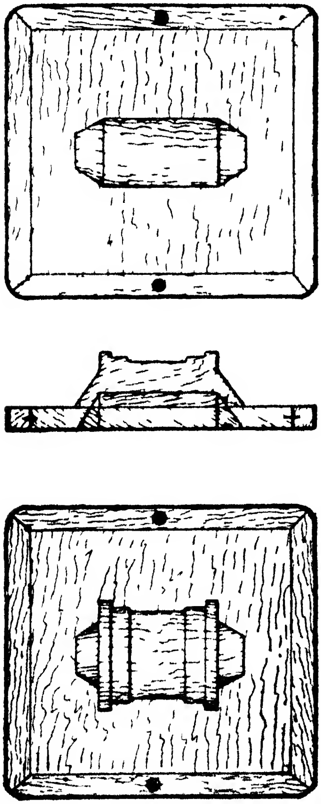


Fig. 508.

Fig. 508 shows how a common brass pattern is sometimes mounted solidly with its board, all alike being in wood. If a pattern is fitted thus to a plate the surface of which is of irregular contour to form the sand joints of the same form, it is not usually a case for woodwork; though fitted thus to a limited extent—the patterns and plates forming integral parts of each other. It is not a very strong affair, but if well made will last a good many mouldings. The pattern is glued and screwed to the plate, and the latter is cut out with the necessary recesses on one side, and raised blocks are fastened on the other side to correspond, or are cut in one with the pattern. If the depth of recessing is not great the plate is not weakened much, but if the wood is cut right through as in Fig. 508, and as must often be the case, we get short and weak grain. In such cases a metal plate and pattern are preferable. But it is not necessary to make a complete pattern of exactly the same shape from which to mould the metal one. The pattern or patterns are necessary, but the plated work can be prepared with

less expense by the method to be described on a subsequent page.

Fig. 509 shows how a cap pattern of metal is mounted on a board with irregular joint faces. Figs. 510 and 511 illustrate the top and bottom parts of the moulds of brasses, shown open in the joint faces with the patterns still in place, as though both in top and bottom. The sloping joints may be formed either by a recess cut in the board, as in Fig. 509, or the patterns are laid on curved blocks, the ends of which form the joints. A difference between these examples is that Fig. 508 is a true plate, moulds of which are taken from opposite sides, while Fig. 509 is a bottom board, on which one-half the mould only is rammed and then turned over to have the top part rammed on it. But if two plates are made, the faces being like the moulding faces in Figs. 510, 511, we should have two moulding plates, on each of which one-half the mould would be rammed. Or if a single plate were made, the opposite faces of which were like Figs. 510, 511, including the pattern outlines, we should have the single plate of patterns similar to Fig. 508.

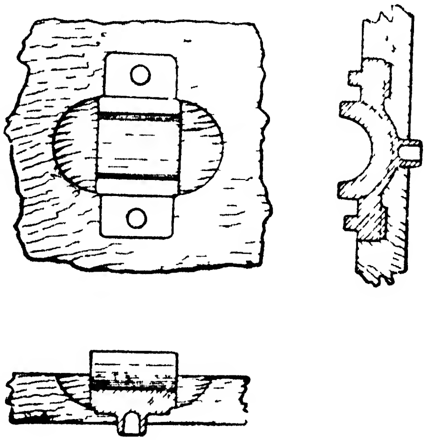


Fig 509.

With regard to plating patterns it is obvious that the insertion of a plate between two portions of a pattern makes no more difference to the thickness of the casting than as though a plate were not used. Thus, in Fig. 512, the joint faces of the moulding box come against the faces, *a*, *b*, of the plate, and when the box parts come together, the joint faces, *a*, *b*, of the half patterns will be in contact as though the pattern had been moulded by turning over.

It is also evident from Fig. 512 that though the pattern parts are shown as being attached to each side of a plate, they might just as readily be cast in one with it. The first method is generally to be preferred when the joint

faces are plain, the second when they are of irregular contour.

The range of dimensions within which it is permissible to put patterns on plates of wood or of metal is of very wide limits. The tendency now is to increase the dimensions of work put on machines, in which direction the Pridmore machines have gone farthest. But as regards the areas of patterns that can be plated to be moulded apart from

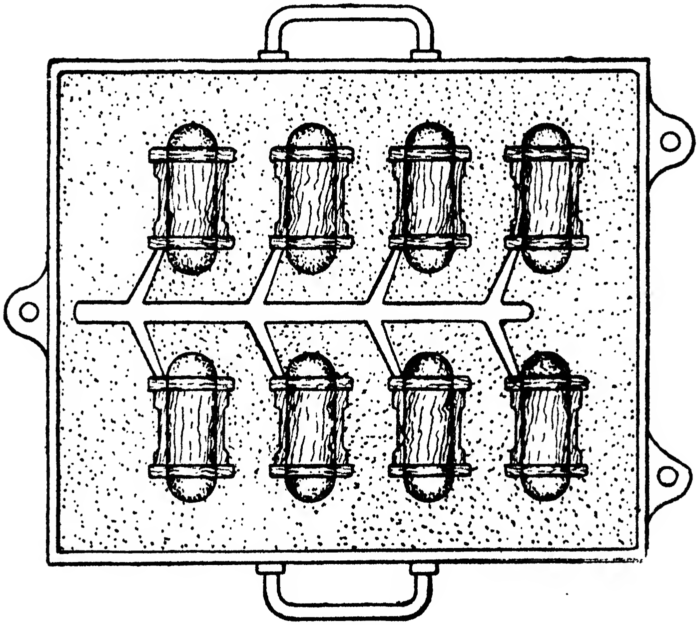


Fig. 510.

machines, these have, within the writer's own experience, exceeded anything attempted on a machine. It has been found economical to plate columns from 12 feet to 14 feet in length, and the plates for water-tank bottoms up to 10 feet or 12 feet across, besides a good deal of work nearly approaching this in size. And apart from actual plating, meaning by that the fastening of patterns to their plates, there is practically no limit to the dimensions of bottom boards which are either kept stored for general service, or made specially for certain jobs often repeated.

The work of plating patterns in wood is done by the pattern maker. That of plating in metal is also properly his work, because he knows best how to arrange the exact amount and place of taper in patterns and prints, and where and how to fit loose pieces when necessary, and to adapt core-boxes to prints. If the work is done by machinists or fitters, any men should not be taken haphazard from the shop and sent to do this, but men specially trained in the intricacies of pattern

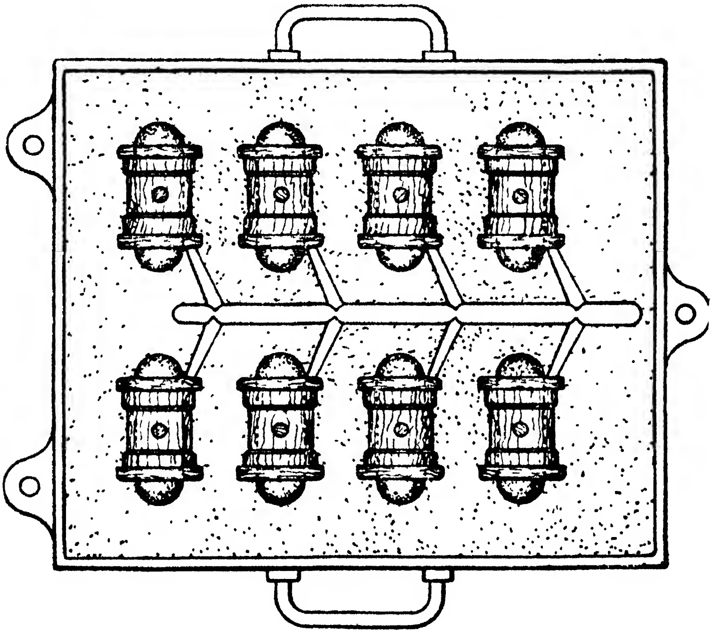


Fig. 511.

making and moulding should be retained for the purpose. The following are concise instructions for the mounting of patterns on plates for use with hand moulding, and for putting on machines :—

Since the thickness of a plate obviously has no effect on the pattern or mould, because the ramming takes place on its faces, the results would be the same whether its thickness were $\frac{1}{4}$ inch or 2 inches. Considerations of strength and rigidity, therefore, to resist ramming without spring, govern the thickness. Generally plates of metal range from about $\frac{3}{8}$ inch to

$\frac{3}{4}$ inch thick. They are made of cast iron or steel plate. The thinner plates are frequently made of sheet iron or steel, which, if levelled carefully, avoids the necessity for planing the faces, which is done when cast-iron plates are used, as is more commonly the practice. Cast iron is more rigid, and it is easier to cast lugs on that than to cut them in sheet metal. In any case the plates must be true on both sides to provide level joint faces for the sand.

To mount patterns of wood on one side of one wooden plate is quite simple. The pattern is arranged suitably in relation to the moulding box, allowing proper width for sand, and is there screwed in place. To mount halves of patterns on opposite sides of one plate much more care is necessary, because a very slight degree of inaccuracy in setting the halves will result in overlapping joints in the mould and casting. Centre lines can be drawn on the board, and centre lines on the pattern parts, and good results obtained by this method. But the most certain method is to fit the pattern parts together first, apart from the plate, using dowells long enough to go through the thickness of the plate and into the hole half of the pattern. Then if holes are drilled in the board to correspond with these dowells, the two halves are bound to be in alignment on the opposite faces. If dowells, for any reason, are not adaptable to the work, the two portions of the pattern are fastened together with screws while away from the joint board. Then they can be separated and fastened together through the joint board by the same screws or by longer ones entering the same holes.

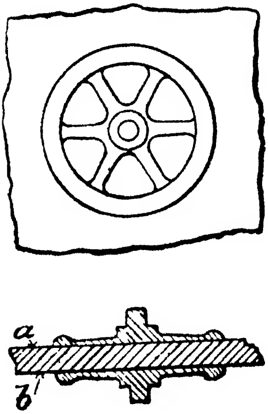


Fig 512.

Metal patterns are mounted on metal plates by methods which resemble in the main those adopted in plating wooden patterns. But, in consequence of the greater importance of the metal pattern work, special care has to be observed and some differences made.

First, metal patterns must be tooled or filed all over with the utmost accuracy, especially when many thousands have to be moulded from them. Parts that can be turned, milled or planed should be so treated, and filing reserved only for those

portions which by reason of their irregular shape do not admit of machining. When a pattern goes wholly in the bottom box there is no trouble with jointing, but when in top and bottom, the pattern parts have to be put together before any tooling is done upon them. It is not usual to fit them with long dowells, mentioned previously as suitable for wooden patterns. The best methods are those illustrated in Figs. 513, 514. In one, Fig. 513, stove screws unite both halves of the pattern, and these passing afterwards through holes drilled in the plate, retain the pattern parts in exactly the same relations. In the other, Fig. 514, plain holes are drilled right through the

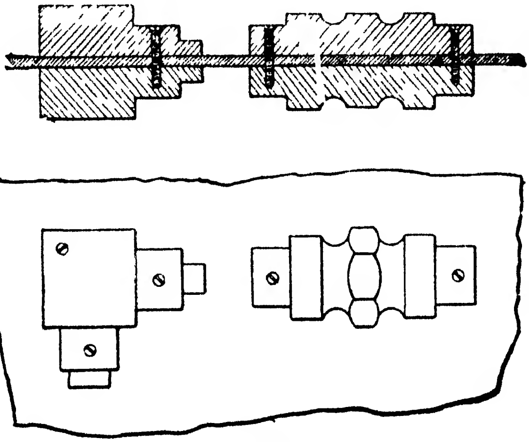


Fig 513.

pattern parts, and these serve to unite the pattern to the plate by means of rivets, the heads of which are filed off flush afterwards.

In numerous cases patterns are of such a shape that though portions come on opposite sides of a plate, they need not be separately prepared and fastened on. A hole through the plate, Figs. 515, 516, receives the pattern through it, and one portion appears on the bottom and one on the top face. Of course in such cases allowance must be made in the length of the pattern, or its print, as the case may be, for the plate thickness, the pattern or its print being lengthened by just that amount.

When pattern parts are placed on opposite sides of two separate boards, or iron plates, as is often done to economise time by employing two men—one ramming the top,

the other the bottom boxes—this work requires even more care to avoid overlapping joints. Then centre lines squared carefully over from one plate to the other can be used to locate the pattern parts. Or the two plates can be fitted together. In this case the patterns will have been fitted with long dowells or screws, or with holes drilled through for long pins, and then these will be fastened on opposite sides of the plates while the latter are fastened together temporarily. Or the pattern parts can be lightly soldered with soft solder in their positions, by centre lines, and a mould and casting made, and then if necessary the positions of the plates can be readjusted and finally fixed with screws.

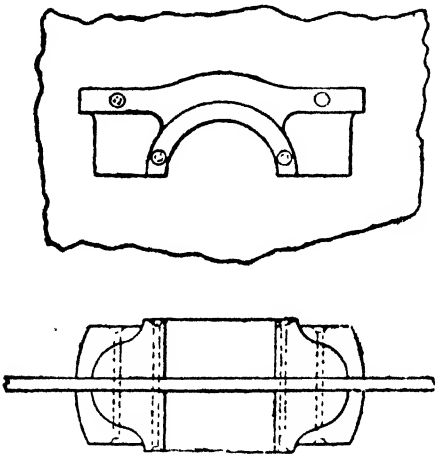


Fig. 514.

When patterns are cast with their plates, which is most advantageous when the joint faces of the plates are irregular, the following are the methods adopted:—

A mould is made by any of the usual methods, just as though castings have to be poured therefrom. Thus, a bottom box may be rammed on an odd-side, the patterns put back into the bottom part, and the top rammed. Or a mould may be made by turning over, rather more time and care being spent on the joints than as though for an ordinary casting, because the joints will be permanent in the metal plate for hundreds or thousands of mouldings. In the case of a plain plate the pattern or patterns can be rammed up on a bottom board. In each case we now have top and bottom moulds prepared ready for the plate—say for four dished hand wheels, the section of one of which, cast with the plate, is seen in Fig. 517. A pattern frame is prepared, Fig. 518, A, of a suitable outline for the particular boxes, or the machine employed, and of a thickness proportionate to the area of the work, and this is laid round the mould on the face of the bottom box. This may be a standard pattern of metal or one of wood. Outside this frame

is another, B, of the same thickness, and of such a size that it will leave sufficient sand space C for ramming round the edges of A, so containing and enclosing the mould for A. When A is withdrawn and the patterns lifted, the mould is seen to contain provision for casting the plate with pattern parts on top and bottom. Runners will be cut to be cast on the plate. During the pouring the frame B remains in place, keeping, with the sand C, the top and bottom boxes separated by that thickness. Instead of using the frame B separate strips of iron of the proper thickness can be laid round on the edges.

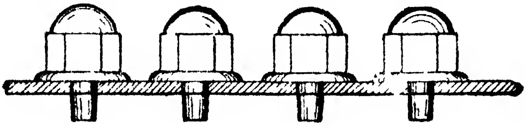


Fig 515.

It is clear that in the preparation of plates of this kind much care must be exercised by the moulder if clean metal patterns and plates are to be obtained. If these, when turned out, are lumpy and imperfect, a good deal of labour will have to be spent in trimming them up with file and chisel. This is why the separate plate and pattern parts are better when plain joints are required. The plates can be planed, ground, or milled, and the patterns machined and filed much better separately than when they are cast in one piece. Besides the disadvantages of casting patterns with their plates by reason of the greater difficulty of cleaning up the patterns, another point is that no subsequent alterations can be made, or the plate used for any other patterns. But casting on is often the only practicable method, and these cases therefore stand by themselves.

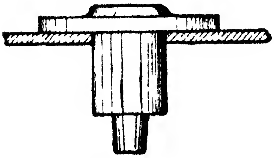


Fig 516.

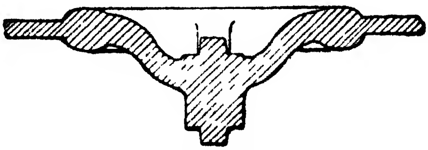


Fig 517.

The lugs of plates are fitted to the pins of moulding boxes or to suit the clamps or pins of moulding machines, details which are settled to suit circumstances. When fitted to boxes, a good plan is to make one of the round pins only to fit closely in a round hole, and make the other hole a slot

hole as in Fig. 518 and Fig. 524, p. 321, in which the pins will fit sideways only, being free to adjust themselves in the other direction. This is just as secure as making all the holes round, and is much easier to fit. Such pins may be cast with their box lugs The slot holes on the other sides are hand holes for lifting by.

The cutting of runners in ordinary moulds has to be repeated as often as the mould is made When several patterns are embedded in one box, a runner has to be cut by

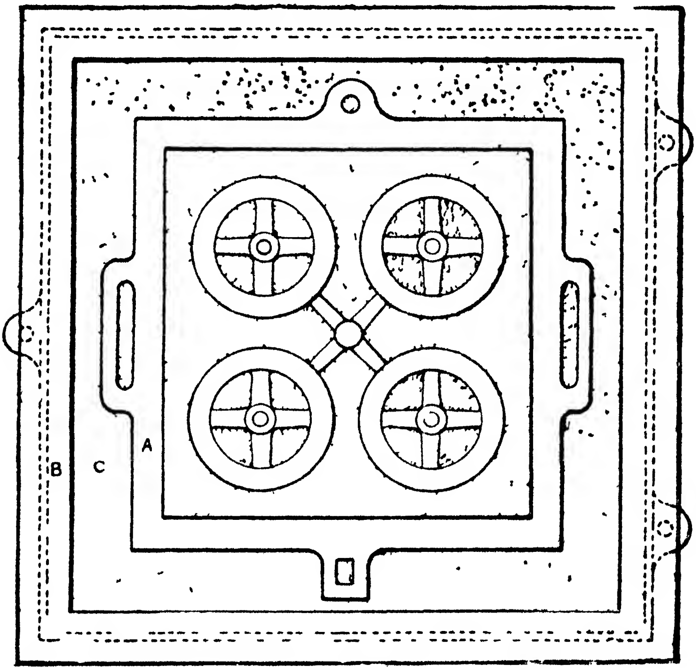


Fig 518.

hand to each pattern. Often, too, a spray of runners must be cut to a single pattern. By a system of plate moulding the cutting of many thousands of runners a year is avoided.

In work which involves irregular jointing of mould faces much time is saved by plating. A moulder cutting and sleeking faces of this character will often occupy ten or fifteen minutes therein. This time is saved if the faces are formed on a plate. Figs. 510, 511, pp. 310, 311, show these in combination, run-

ners, and irregular jointing being repeated for eight patterns of brasses. In moulding by common methods such half brasses are laid on the follow board on a little body of sand, which is sloped outwards and downwards to give a free delivery to the joint that follows the curve of the bore, and this has to be repeated for every mould, and the runners also have to be cut for each mould—time which is saved by plating. Moulds in which a square section merges into a circular one, as in much valve work, require a sloping joint, which must either be made up on the follow board or by bedding in a false mould—all saved in plate moulding.

In the average class of brass work, cored castings are frequent, and several cores will often be inserted in a single casting, and cores fitted into other cores, suitable vent channels being provided. When plated castings admit of the alternative of coring or of self-delivery, it is better to adopt the

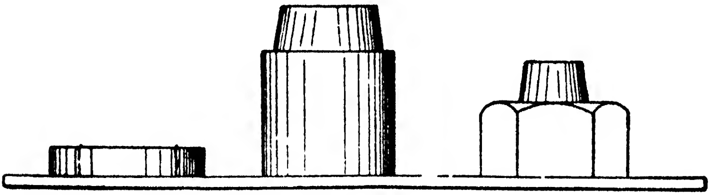


Fig. 519.

latter device. When holes have to be bored in rings, collars, shallow bushes, and the like, a little taper, sufficient in amount to ensure self delivery, is not detrimental, and such patterns are made like their castings. When holes must be perfectly parallel it is difficult to make them deliver, even though they are very shallow, and then a core is best. Thus, in Fig. 519, which represents three plated patterns, the shallow ring should not be cored, but the bush must be. The nut must also be cored, unless a rather large amount of taper is imparted.

The stripping plate is a device used to permit of the withdrawal of deep patterns destitute of taper. It is cut in sheet metal, and makes a close fit outside the pattern. A familiar example is the plate that encircles the teeth of gear wheels moulded on machines, the same device being employed for most deep patterns where the putting of taper would be objectionable.

The labour involved in making stripping plates is sometimes avoided by the employment of what are termed vibrator machines. That is, the patterns are vibrated at the time of withdrawal by shaking or rapping a frame by power—by compressed air, which imparts a number of light shocks with great rapidity. But this is not a device suitable for patterns of great depth, for which the stripping plates are indispensable.

The expense of fitting stripping plates to patterns is usually great, depending on the pattern outlines. Only outlines that are regular, as circles, squares, etc., can be tooled cheaply, others have to be finished by hand labour. Stripping plates are useless unless they fit very closely round their patterns.

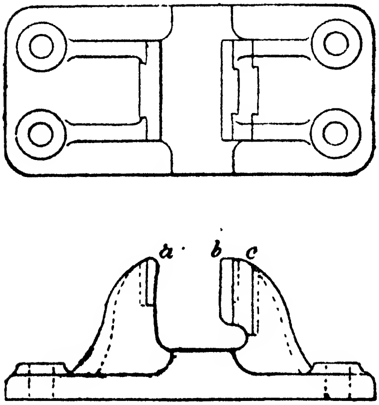


Fig. 520.

The objection to stripping plates on the ground of their expense only carries weight when the machine is used for relatively small quantities of work of a given kind. Where moderate numbers of small pieces are made, as in many shops of rather general character, then rapping the plates by hand is resorted to.

Railway chairs are examples of high-class metal patterns made without regard to expense, because hundreds of thousands of castings have to be moulded from them. They are moulded by two sets of men, one ramming the bottom, one the top boxes. They are put on plates, and often made on the floor without the aid of a machine. No coring is done. because that would cost too much, but everything delivers itself. Loose pieces, Fig. 520, are therefore involved. The pattern-maker will understand why one loose piece suffices on one side while two have to be fitted on the other. The overhang is so slight where the wood key fits that one loose piece, *a*, suffices, on the other the overhang is greater and one piece would be too thick to draw in, hence the jointing in two separate pieces, *b*, *c*. Note, too, the dovetail fitting of *a*, *b*, *c*, which ensures the maintenance of flush edges without any care or observation on the part of the moulder.

Fig. 521 is a chair of another pattern in which one of the horns is fitted to the foot with a tenon, with the idea of facilitating the withdrawal of the main body of the pattern. It possesses little or no advantage over the other method.

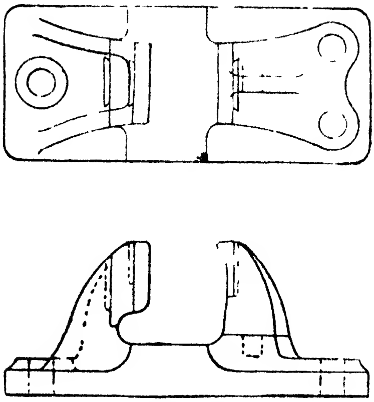


Fig. 521.

Fig. 522 illustrates a device of a different character. Here the removal of the loose pieces from the mould is facilitated by soldering strips of metal, A, A, to them. The strips pass through slot holes in the foot of the pattern. This helps the moulders' work. The loose piece, *a*, still has to be removed with the fingers, but it is on the horn where the space is widest, and the moulder can therefore get his fingers down more readily. The holes for the spikes deliver themselves. The section of the pattern also shows how the interior is lightened out to lessen the weight, the pattern being lifted by hand.

Fig. 523 shows the type of box used for moulding chairs, in which sand and time are economized by tapering the sides. The plates which carry the patterns are set on the box parts by the tenons and guides with which the boxes fit to one another.

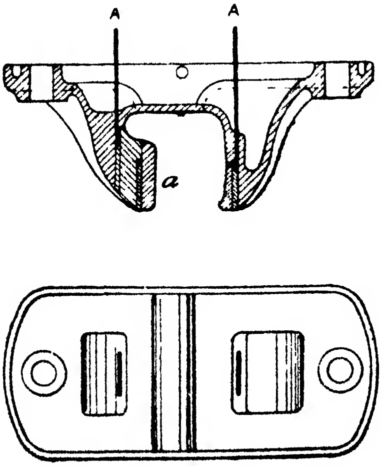


Fig 522.

Fig. 524 is a metal plate carrying ten nuts and their gates. The general forms and mountings of plates may be inferred from the foregoing. There yet remains the question of economy.

With regard to the economies of plate moulding, which is a point the pattern-

maker often has to decide, there is a wide actual difference, and also much difference in the opinions held with regard to certain classes of work. We may disregard the latter, and look at the question from a broad common-sense point of view.

Primarily the proper case for plating patterns is when large numbers are in question. This is always the first consideration. When instead of two or three moulds having to be taken from one pattern, scores, hundreds, or thousands are wanted, there

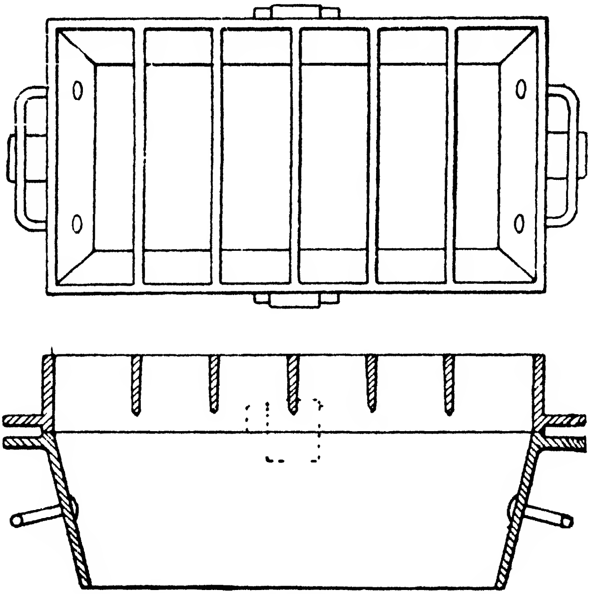


Fig. 523.

is a *prima-facie* case for plate moulding, to be done either with or without the aid of a machine. But though patterns of large dimensions may be plated with economy, they cannot usually be moulded on machines, because these of large size are exceptional. Then again the simplicity or otherwise of the work has a determining influence. Moulds that involve a deal of coring up would not show such economies as those of a plainer character, because the work of coring cannot be done by machine, but must be effected by hand alone. Plain patterns, that is those which are not complicated by loose

pieces, drawbacks, and numerous cores, are the best. Shallow patterns that deliver easily are also very suitable for plating; deep patterns present difficulties which can be got over by the device of a stripping plate—a rather expensive device, but which, nevertheless, enables deep patterns to be withdrawn without any appreciable amount of rapping, and without fracture of the sand. The greatest economies of plate moulding occur, when many patterns are put on one plate, when the runners are included thereon, and when the joint faces are not plain.

Many patterns are included on one plate in the smaller castings made in iron and in brass. These are usually arranged also to occupy the least room possible, hence the reason of the diagonal positions often given to the patterns, and of the insertion of small patterns in open spaces left between larger ones. In a well laid out plate not a bit of space is wasted or occupied by useless sand if a pattern can be put there. This is illustrated in the odd-side Fig. 503, p. 304, and in Figs. 505, 506, p. 306, Fig. 507, p. 307, Figs. 510, 511, pp. 310, 311. The ramming up of such a plate occupies very little longer than the ramming of a single pattern or of two or three patterns. If we include the work connected with making the runners in an ordinary mould it occupies less time, so that the output is multiplied often dozens of times when many small patterns are plated. Against this the cost of the plate and of the moulding machine, when such is used, has to be discounted. But these, though expensive, are mere trifles by comparison with the economies obtained in shops where the system of plate moulding is in constant operation.

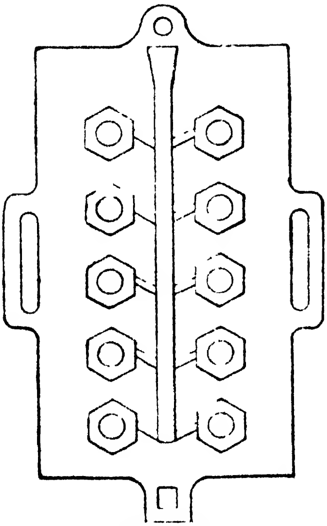


Fig. 524.

The advantages also of plating over the various joint boards are great. One of the very common devices in the brass foundry is the recessed turn-over board. Many small patterns are made without joints, in brassfinisher's work—as cocks, valves, plugs, and so forth. The mould, however, has to be

jointed, though the patterns are not, and, since they are made in quantity, they are rammed up on a turn-over board which is *recessed out* to receive a number of such patterns at once. The patterns fit loosely into their recesses, and their centre joint lines correspond with the face of the board. The ramming up process is by turning over. Fig. 525 shows such a board, having some patterns, *a*, *b*, *c*, *d*, *e*, *f*, *g*, *h*, *in situ*, and some spaces, *i* and *j*, from which the patterns have been removed. A section through another board of this type is shown in Fig. 526. Patterns of the same size and class can be similarly arranged, but it is often more economical to have

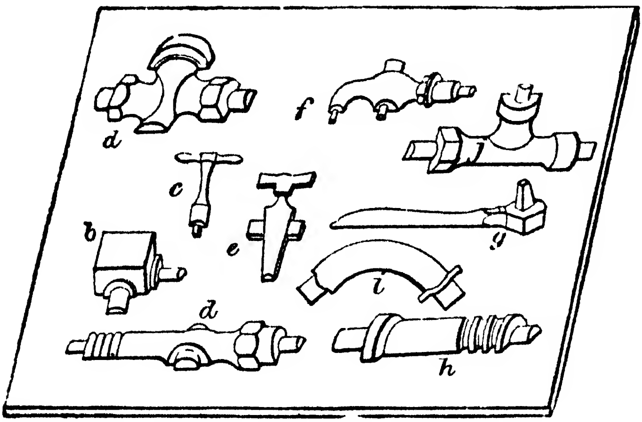


Fig. 525.

different patterns on a board and stop off those which are not required. No alteration can be made in such a board. The labour of recessing it out is considerable, and would go some way towards making a metal plate and patterns. But in using plates, whether of wood or metal, the patterns in each case may be put permanently on their boards or plates, or they can be attached temporarily and removed therefrom after service to make room for other patterns of dimensions suitable for those boards, and so several patterns may be thus interchangeable on one board or pair of boards. Not so the recessed boards.

Moulding machines are either operated by power or by hand. They are also fixed or portable. For the generality of work, certainly for all deep work, some special cases

excepted, the hand ramming machines are the most satisfactory.

When ramming patterns on a machine in which the sand is consolidated by pressure from a head pulled against the pattern by a lever, the following devices are adopted:—The sand is shovelled in to an inch or more in depth above the back edge of the box and confined at the sides by a temporary frame. A pressing board that just fits easily with the frame

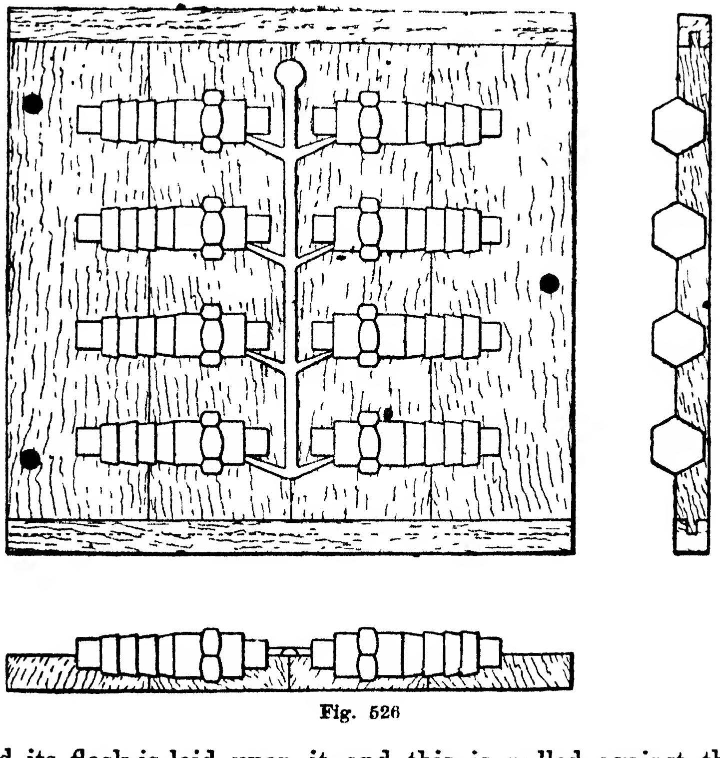


Fig. 526

and its flask is laid upon it, and this is pulled against the board, consolidating the sand down to the level of the flask. Considerable force has to be exercised in large moulds, therefore the levers are of great length, or, as in the Tabor and some other machines, the force of compressed air or of steam is used. When a mould varies greatly in depth, the pressing board or plate is sometimes hollowed out to follow roughly the contour of the pattern, without which precaution the sand would be rammed harder over the shallow than the deeper

areas. In some cases provision is made by means of narrow strips for consolidating the sand next the edges of the flasks to afford support to that within, and to cause it to cling better to the sides.

There is undoubted advantage in making use of power ramming in some classes of work; for others it would not be suitable, or it could only be rendered suitable by employing some provisions too elaborate to be worth while adopting.

In some cases there would be an advantage in having portable machines, in others none. These are excellently adapted for handling the lighter classes of work and are therefore growing in favour. Being mounted on wheels they are moved on, leaving the finished moulds on the floor in the rear.

In some cases a single class of machine can best be installed throughout, but in others it will be advisable to have different types, as better adapted for the different kinds of work done. In all such questions it is well to take the advice of experts. Points which should have consideration in the selection of a moulding machine are to see that sand does not come into contact with working surfaces, as shafts, journals, bearings, or slides. It is well when such parts are above the sand instead of below. The position of the levers is a point of some importance. It is better that a lever should be in the horizontal position when the mould is being pressed, because in that position the operator is able to exert more pressure with less exertion than when it is in a vertical, or nearly vertical, position.

There are a few shops which deal with so varied and general a class of jobbing work that it would be injudicious to recommend the installation of moulding machines at all. But there are not many foundries, perhaps, in which some work cannot be put on a machine, and the number of the outside country jobbing firms is bound to diminish in time as manufacture of specialities increases.

Tub Moulding.—This is a foundry name given to the moulding of small items of a light and generally rough appearance. For cheapness, the patterns are "sprayed," *i.e.*, linked together after the style of those seen in Fig. 526, except that the finish and arrangement is not so symmetrical. Owing to the smallness of the cross-section of these "sprays," no time need be spent in the foundry on venting and trimming the mould or making risers and vents.

CHAPTER XXVIII.

MOULDING MACHINE PRACTICE

Various Methods of Operation—Presser Heads—Delivery—Rapping—Stripping-plates—Machine-tables—Patterns and Pattern Mountings—Examples of.

MOULDING machines are operated in several ways. It is difficult to adopt an exact classification, but the following will answer all practical purposes. Moulds are rammed by hand, and the pattern is delivered by a hand lift. The sand is pressed mechanically by means of a lever or other mechanism, and the delivery is by a hand lift. These types are used very largely in light snap flask work. Patterns are also rammed by hand, and delivered by mechanical means, as by a lever, or by hydraulic or pneumatic mechanism. These occupy a very extensive field, probably the largest, and include the whole of the extensive range from those of small dimensions to the largest. Or again, they are rammed wholly by power, and the pattern is delivered by hand-operated mechanisms. And power is also used both for ramming and delivery. In most cases the mechanism which rams is also utilised for lifting. But in the heaviest machines of hydraulic type, separate rams are used for ramming, and lifting, with resulting economy of power, and reduction in the height of the machine, a matter which is of much importance in massive machines, some portions of which have to be sunk below the floor level. In such cases a large central ram performs the compression of the sand, and two smaller side rams the extraction of the pattern.

Outside of these is a new type, the jar, or jolt-ramming machine, in which no ramming is done, but in which the sand is compressed by a rapid and vigorous jarring of the moulding box with its contained pattern and sand on an iron anvil. This does not fracture the sand, as a pattern-maker might be disposed to think. It would do so but for the adoption of certain precautions. Cushioning on springs

is the principal one. There are also relations to be embodied in the mass of the moulding-box with its contents, and the mass of the anvil, and the support afforded to it, in the number of jars, and in the depths of moulds. When these are duly proportioned the results obtained are superior to those of direct ramming. The sand is consolidated more closely in the lower portions than in the upper. A curious fact is that no venting is required, which probably follows from the comparative openness of the sand in the upper strata. Actually a little hand ramming has to be done over that. As may be supposed, this method is more suitable for deep work than for shallow, and, of course, only for articles which have no projecting portions standing out laterally. But deep vertical sides, which offer difficulties in power pressing, can be jar-rammed very well.

Presser heads have to be used in all machines which embody mechanical ramming. There is much variety in the design of these. They are usually hinged in some way in the smaller machines in order that they may be thrown backwards when box parts are being put on or removed from the table, and to permit of the sand being dumped into the box parts. In the heavier machines other methods are adopted. The usual one is to run the presser head backward and forward on trolly tracks. Another way, employed less, is to swing it sideways on a pivot. The height of the presser head in most machines is adjustable within a good range in order to accommodate moulds of varying depths. A very strong and rigid resistance is provided to withstand the pressure between the head and the mould. The pattern-maker frequently has to cut blocks of wood for the presser head. A perfectly flat piece of plank is not suitable for deep moulds, in which some portions stand up very much higher than others. The sand in this case would be looser in the lower portions than in the upper. Some hand ramming is then done by the moulder. But the presser head is also cut approximately to the contour of the upper portion of the pattern in order to equalise the pressure all over.

With regard to delivery, a great many differences exist. First there is the question of direction of delivery, whether upwards or downwards. It is answered differently in different machines. Usually it is more convenient to draw the pattern downwards, so taking advantage of gravity.

But in a few machines the box is lifted off the pattern by means of studs. Delivery by a hand lifting of the top box, and then of the pattern from the bottom box is adopted very generally in the moulding presses with snap flask work. But this is always of small dimensions. In nearly all other cases the lift is mechanical, and herein one of the great advantages of the moulding machine lies. The risk both of fracture of the mould and of its enlargement are vastly minimised, and all moulds taken from a pattern are practically alike, which is not usually the case in delivery effected by hand.

Rapping of some kind has usually to be done. This is generally a rapping on the pattern table, done with a wooden mallet during the act of withdrawal. But a large number of power-operated machines are now fitted with a mechanical vibrator which employs compressed air. The vibrator is a piston moved rapidly backwards and forwards in a cylinder attached to the underside of the table, and set in motion by the knee of the attendant. It assists delivery without making any measurable difference in the dimensions of the mould.

But the greatest obstacles to accurate delivery occur in deep moulds with vertical sides, or those which have portions projecting laterally. In the first kind, stripping-plates are required, in the second, the usual devices of the pattern-maker must be employed, that is either loose pieces, or core prints placed underneath the projections. The adoption of loose pieces precludes the use of power ramming. The sand beneath the loose pieces must needs be rammed by hand, even though power pressing may be adopted above them. The employment of prints beneath is adopted more frequently in patterns for machine moulding than in those moulded by hand, in order, of course, to utilise power ramming.

Deep patterns with much convexity, or with plenty of slope to the sides do not require stripping-plates, but those with vertical faces, even though comparatively shallow, do. Many of these plates are made in wood by the pattern-maker. They are framed together at the corners, and the interior edges are cut to the outline of the pattern which has to be drawn through them. They will endure better if soaked in melted paraffin.

The metal plates are made in different ways. The most

expensive way is to file the interior edges to the pattern outlines. Many firms now cast them with a clearance and a ledge, and pour a white metal in around the pattern. A little trimming is all that is then required, and the plates are very durable. Internal stripping-plates are used also in the case of deep parts, as in the spaces between arms and framings, etc. Instead of mounting these on the machine-table they are carried on stools of suitable shape, and located underneath the table.

The pattern-tables of machines are of two types, the turn-over, which is the more common, and the fixed. The first permit of mounting pattern halves or parts on opposite sides. One box part is rammed first, and the table with that part is turned over, and the second box part placed on, and rammed. In some machines both top and bottom box parts are rammed simultaneously by one squeeze. If a pattern is unjointed it may be placed on one side only of a turn-over table, in which case the table is usually turned over to ram a plain top with its ingate on the opposite side. The non-turn-over tables are preferred for the heaviest machines. In these the patterns must be changed on one table for cope and drag. Or the two box parts must be moulded on separate machines. Or, when the shapes and dimensions permit, the cope and drag box parts are arranged on the same table side by side, and rammed or pressed simultaneously.

Patterns for machine moulding are often identical with those used for plate moulding, described in Chapter XXVII. If for the plates of wood or metal described in that chapter the table of a moulding machine is substituted, and the patterns mounted on it, they could be machine moulded. But that would not nearly cover the field which is occupied by the latter. In many cases the pattern parts are not attached to the machine-table at all, but to an intermediate pattern-plate which is pinned to the table. In others the table is a frame only, through the opening in which the pattern-plates are fitted. The frame is then made as a stripping-plate which may be plane, or of some irregular form when down-jointing has to be done. Also the thicknesses of the patterns, or parts of the pattern, are not the same as those of the castings, but more by the thickness of the stripping-plate, or by as much of the pattern as goes into the plate. The difference between patterns made for hand and for machine moulding may therefore be

nil or nearly inappreciable. Or in their highest developments they may be such that considerable study is necessary to recognise the resemblance and relations of separate pattern parts to the finished casting.

The group of Figs. 527 to 533 shows the moulding of axle-boxes on the Pridmore machines. The casting is shown in Fig. 527. If moulded by hand in the ordinary way the pattern would have the same shape. It is done on the machine in the manner shown by Figs. 528 to 533; Figs. 528 to 530 represent the work in the bottom or drag, Figs. 531 to 533 that in the top or cope. A comparison of these views with the casting will enable the relations of the parts to

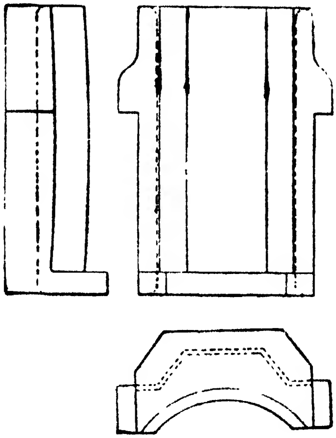


Fig. 527.

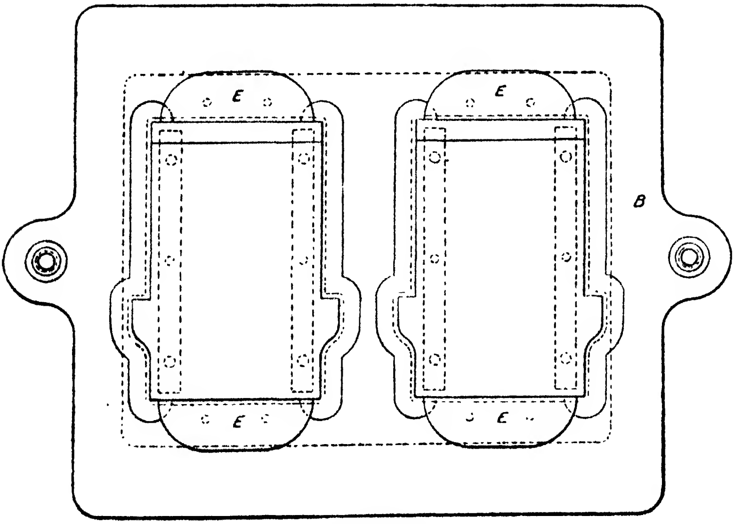


Fig. 528.

be understood. The drawings illustrate several essential features which have their applications in patterns that

differ widely in shapes and outlines. In this machine as in many, the table is not made solidly to receive the pattern parts directly, but they are fastened on pattern-plates or frames which are moved upwards or downwards relatively to the table.

In Figs. 528 to 530 the main open frame A, or table of

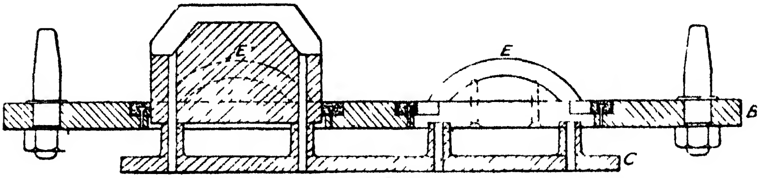


Fig. 529

the machine carries the stripping-plate B, which is changed for different jobs, and the pins of which receive the drag or bottom of the moulding box. Two drag-pattern parts are shown side by side, being moulded therefore in one box, covered by the two top moulds, Figs. 531 to 533. These are carried on the pattern-plate C, which is, in turn, attached to an essential portion of the machine termed the yoke, D. This is moved up and down by the mechanism of delivery, upwards for ramming, downwards for delivery, by combinations of levers and springs in these machines, the details of which do not concern us here. At the right of Fig. 529 one of the pattern parts is removed, leaving visible one of the jointing pieces E on which the sloping joints at the ends of the bore are rammed. These are seen in plan in Fig. 528, and in longitudinal section in Fig. 530. These are blocks which are cut and screwed to the stripping-plate. In Fig. 529 the fitting of the white metal into the recessed portions of the iron plate is shown. The nails seen serve to retain it in place. This method is now very commonly adopted, being inexpensive and practically as serviceable as filing or tooling an iron plate to shape.

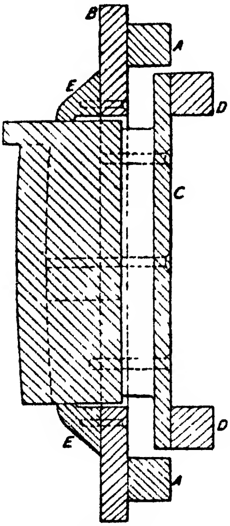


Fig. 530.

In Figs. 531 to 533 the fitting of the cope portion is shown, the same reference letters indicating similar parts, A the machine frame, B the stripping-plate, C the pattern-plate, D the yoke, E the sloping end joints. In this case the

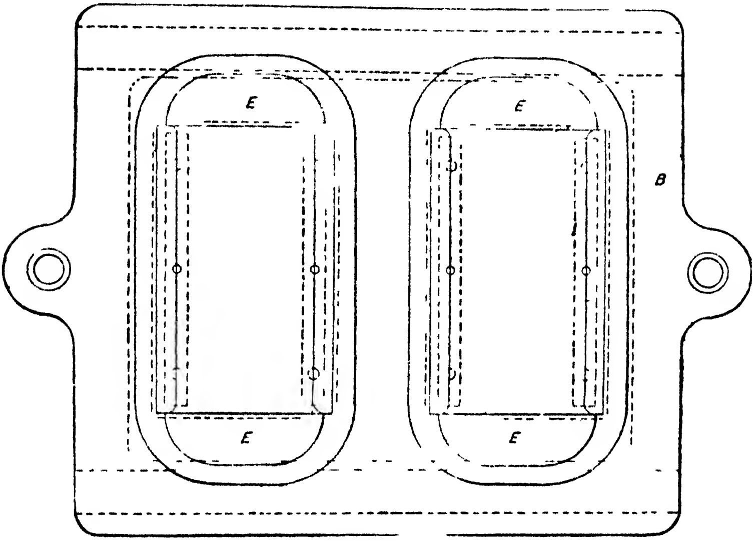


Fig. 531.

stripping-plate is cast roughly to include the slope of the end joints, leaving space for the white metal which is cast to fit the ends in Fig. 530. The holes in the plate which receive the moulding-box pins are bushed.

Figs. 534, 535 show pattern mountings for a spur gear.

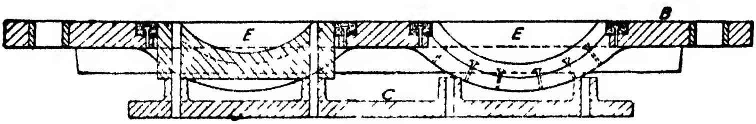


Fig. 532.

Fig. 534 represents the portion which forms the bottom or drag, Fig. 535 that for the top or cope, the relations of which are readily understood. Here as before, A is the machine framing, B the stripping-plate, C the pattern frame, and D the yoke frame of the machine which is lifted and lowered as previously stated. The depth of the teeth in

Fig. 534 exceeds the depth of the cast teeth by the amount by which the pattern enters the stripping-plate. The latter has the white metal lining fitting around the teeth. The inter-arm space is divided into two thicknesses, one half being moulded in the cope, the other in the drag. The pattern parts corresponding with these are drawn through internal stripping - plates termed stools, seen in both Figs. The stools are cut, of course, to suit whatever shape the arms may be. They are bolted to stool bases which are carried by the machine body.

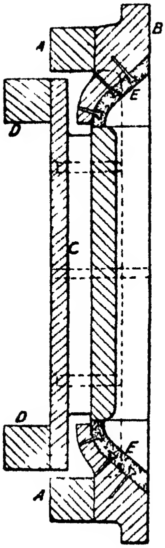


Fig. 533.

Examples of wooden stripping-plates and stools are given by Fig. 536. Very often wooden stripping-plates are made as frames and laid upon a moulding machine framed table to encircle the pattern. In this example (Fig. 536), an iron frame is prepared with recesses into which the pieces that form the actual stripping frame are screwed, being a cheaper alternative to the white metal. The stuff is soaked in paraffin wax. Instead of the single thickness shown, two thicknesses with the grain crossing are frequently used. The patterns are deeper than the castings by the amount of the thickness

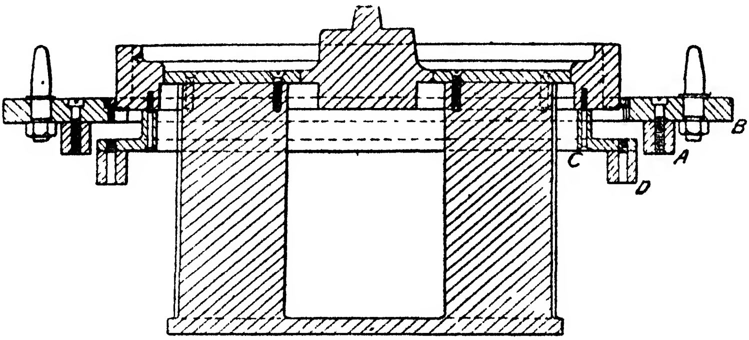


Fig. 534.

which goes down into the stripping-plate. They are mounted on a wooden pattern frame. The stools of wood are mounted on a wooden yoke frame.

Work which requires three-part boxes is illustrated by Figs. 537 to 540, and also the use of a pattern mounting, or false part, and a stripping-plate. The false part A is bolted to the table of the machine which is of the turn-over type. It receives the pattern B for the drag, surrounded by a stripping-plate C. The bottom or drag box part D is put

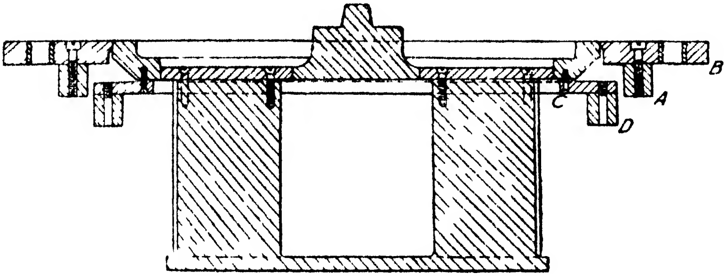


Fig. 535.

over, its pins passing through the lugs on the false part into the holes in the table of the machine. It is then rammed, and a carrying-off plate E is bolted to it. The machine-table is now turned over, the connections released, and the

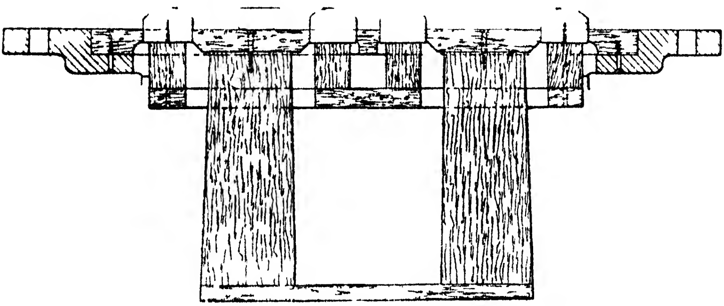


Fig 536.

mould which contains the wheel teeth, arms, rim, and boss is lowered away from the pattern, along with the stripping-plate.

In Fig. 538 the top or cope is seen rammed. This includes the trolley wheel portion F, which is cast in one piece with its false part G, and carried on the turn-over table. This is encircled by the middle box part H and rammed, after which the top, J, is put on and rammed, Fig. 539. The top is next

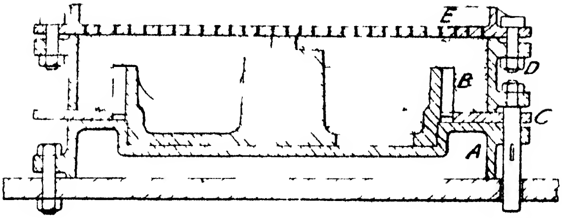


Fig 537

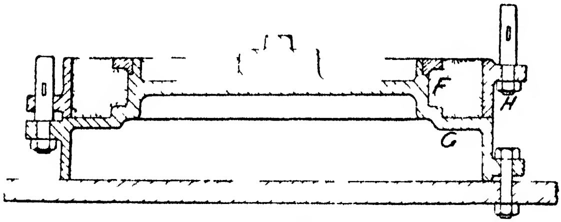


Fig 538

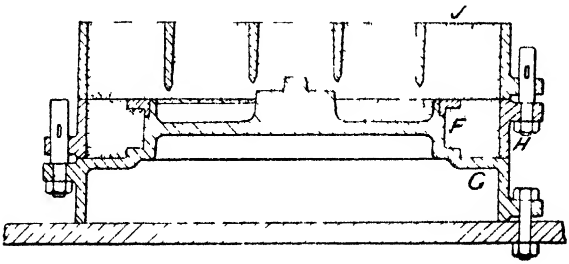


Fig 539

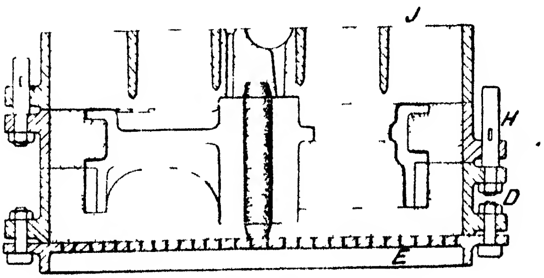


Fig 540.

lifted off and the loose flange removed, the top replaced, cottered, and turned over The connections between the middle part and the false part are then released, and the middle and top part are withdrawn downwards from the pattern, taken away and set over the bottom, completing the mould as in Fig. 540 This was done on a Darling and Sellers machine.

Fig. 541 shows the method of mounting a chilled truck wheel, but the drag or bottom mounting is superimposed

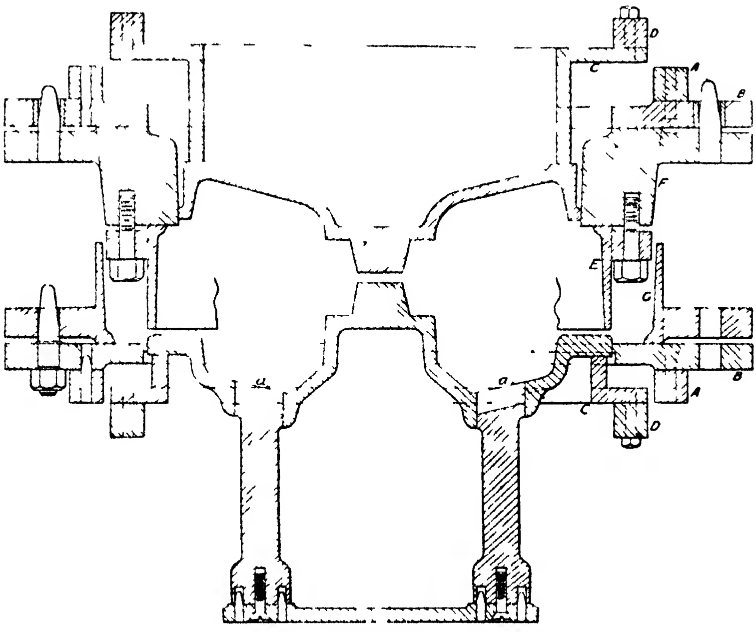


Fig. 541

upside-down on the top or cope mounting, in order to illustrate the coincidence of parts. Comparison with Fig. 542, which shows the closed mould will render the relationships clear. This is a piece of work which was done on Pridmore machines. The same reference letters are used as in Figs 528 to 535. A is the machine framing, B the stripping-plate, C the pattern-plate, and D the yoke frame. The portion of the pattern which forms the cope terminates at the centre of the radius of the edge of the flange, compare with Fig. 542. It is carried on the yoke frame, by means

of which it is raised for ramming and lowered for delivery. The lightening holes *a*, *a*, are stripped by stool posts. The thickness of the metal in the pattern has no influence on the thickness of metal in the casting. E is the cope moulding box.

The drag portion shown above is also carried on a pattern frame and yoke frame. Only the dished portion of

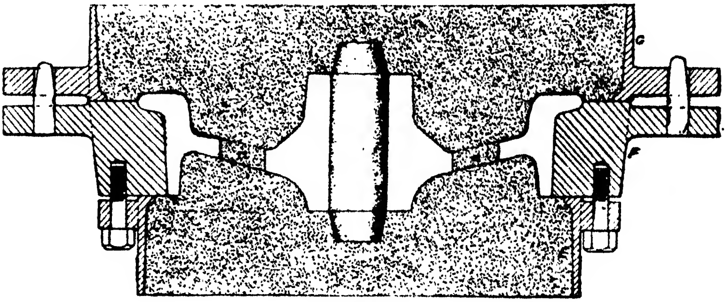


Fig. 542.

the web, and the corresponding inner edge of the rim is made by this portion. The tread is formed by the chill F, within which the drag portion of the pattern slides. Though it is shown on a stripping-plate the latter fulfils no function in this case, the pattern being drawn through the chill. The flask G for the drag is bolted to the chill, so forming a permanent fitting to it.

Fig. 542A.
"Wadkin" Gear Milling Attachment at Work on a Bevel Gear.

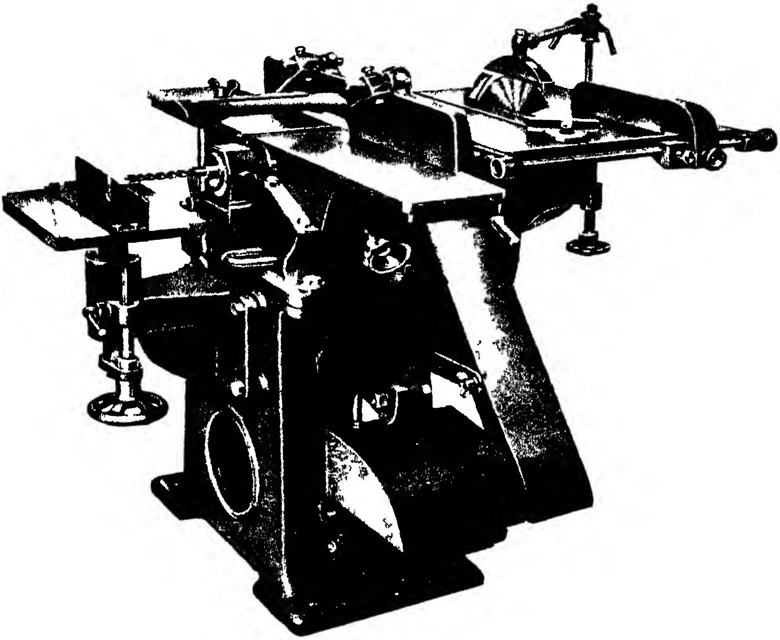


PLATE I.—Machines of the multipurpose type are growing in popularity. The example illustrated combines a 10 in. saw bench, 6 in. planer, rebating machine, slot mortiser and a boring machine.

Courtesy Modern Woodworking Machinery Co., Leicester

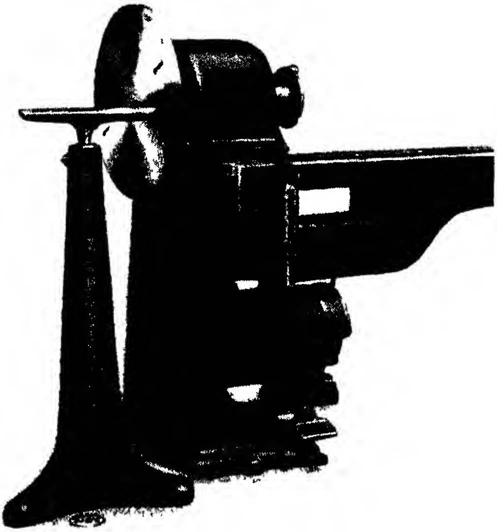


PLATE II.—Outside turning plate and tool rest of a popular wood turning lathe

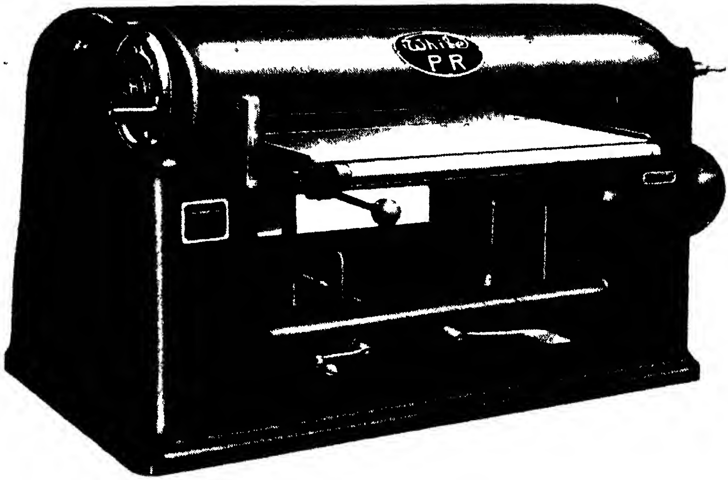


PLATE III. For the really accurate planing of timber rigidity is essential. Note the sturdy frame of this example.

Courtesy Thos. White & Sons, Paisley

PLATE IV. Type NEA9 band saw ready for operation. This shows a machine both modern and pleasing in appearance.

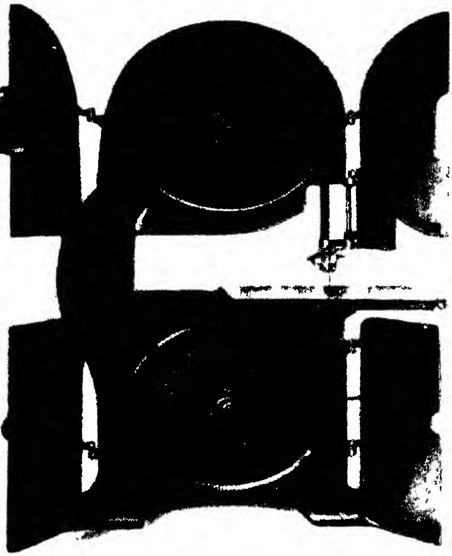


PLATE V.—"SAGAR" NEA9 band saw, shown with pulley guards ope

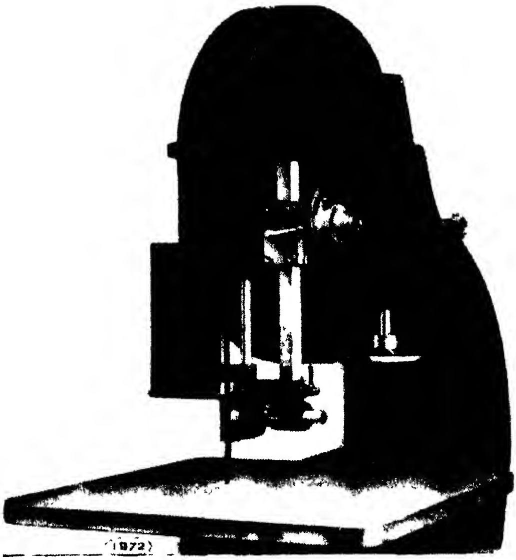


PLATE VI.—Showing the blade guides and tensioning device on the band saw seen in Plate V.

Courtesy, Sagar & Co., Halifax.

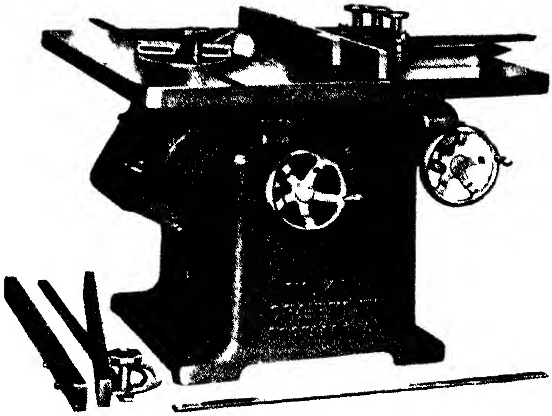


PLATE VII Tilting-arbor electric variety saw.

This design is an answer to the inconvenience of using a circular saw on a *tilted* table Here the arbor motor and saw comprise one unit which is capable of vertical and angular adjustment the table remaining horizontal all the time Micrometer adjustment on the angular setting is provided and this results in really accurate wood work

Courtesy Messrs Greenlee Bros & Co Rockford Illinois, U S A

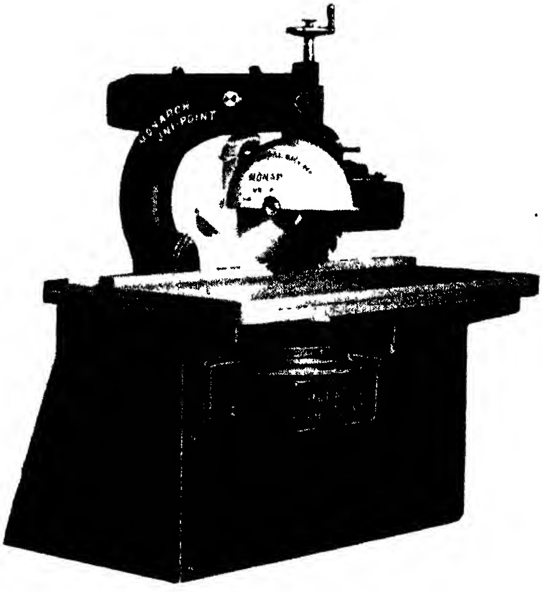


PLATE VIII —" Uni-Point " radial saw

Much attention has recently been given to accurate cross cutting saws, and a special feature of the example shown is, as its name suggests, that it always cuts at the *same point* on the table whether set for vertical, horizontal or angular work. This effects a great saving in time and effort.

CHAPTER XXIX.

PATTERN-SHOP EQUIPMENT.

Circular Saws.—Circular-saw Benches.—Band Saws.—Planing Machines.—Lathes for Wood Turning.—Pattern Milling Machines.—Boring Machines.—Sanding Machines.—Dust Extraction.—Tool Grinding.—Speeds.—Other Accessories.

At one time the humble outfit of joiner's tools represented the complete equipment of the pattern-maker. To-day, however, the smallest shop has at least its improvised saw bench, while in the really large shops an electrically driven assembly of specialised machines await operation.

It is not suggested that the modern pattern-maker is less skilled; rather it is that the pressure of competition will not allow him to carefully gouge out, say, a core-box, when the machines at hand will do the same job equally well in a fraction of the time (see Fig. 109A).

The object of this chapter is to make the reader acquainted with the latest practice in this direction, for, although the equipment of an ordinary saw-mill could be used for pattern-making with success, the machines illustrated in this chapter will be found to have been designed specially for the purpose.

Saws.—For the simple operation of cutting material to size, two saw benches are really required; a rip saw for cutting lengths along the grain of the timber, and cross-cut saws for reducing timber to shorter lengths.

If there is not sufficient work to justify the inclusion of two machines, one can be used, the operator merely changing the saws as required.

The size of the actual saw would be selected with reference to the probable requirements of the shop. For light work, a diameter of 18 inches to 26 inches might be satisfactory, or where carpenters also have to make use of the plant a 36-inch

saw would be better. It is wise to choose a saw on the full side rather than the reverse, to be prepared for emergencies.

Circular saws do not always receive intelligent attention. While it is quite legitimate for a mechanic to wedge the saw in the bench, and then to lightly " touch up " the teeth with a file, this should not be allowed to become the recognised method of sharpening.

A good-class saw with its periphery concentric with its bore will cut cleaner and with less effort, because every tooth will be doing its work. If, by successive filings, the periphery has become eccentric or various teeth or groups of teeth have been filed low, the saw cannot cut so freely, only a proportion of the teeth being in action.

If there is not sufficient work to warrant the outlay on a proper saw grinder, the saws should be sent periodically to a reliable firm : the actual makers are best, so that they are kept both sharp and true.

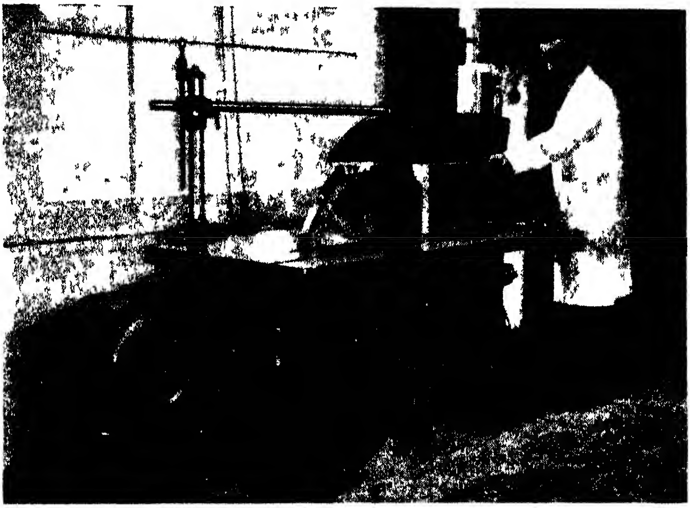
In filing the teeth of a rip saw, the edges are kept at right angles with the sides of the saw. For cross-cut saws a slight angle is better.

The gullet or circular portion at the root of the teeth should be preserved, first to provide clearance for the sawdust, and thus prevent " binding " or clogging, and secondly, if, when filing, the round shape has become angular, or in any way " nicked," there is a danger of a tooth breaking when a knot is encountered.

The " set " or lateral displacement of the teeth is accomplished by means of a tool designed for this purpose. The amount of set can be varied to assist the passage of the saw through the timber, if using it in a damp condition is unavoidable.

Dealing with the actual benches, in common with all things mechanical, advances have been made in the design. Ball bearings displace solid ones, individual electric motor drives displace the belt, and a host of minor refinements have been made, which make for smooth and accurate working.

Fig. 543 is an example of a modern 36-inch. saw bench, made by Messrs Wadkin, of Leicester. Its rigid and compact design at once catches the eye. The saw spindle is mounted on ball bearings in dust-proof housings. It is also extra long at the front for taking grooving heads, cutter blocks, etc., thus widening the range of its usefulness.



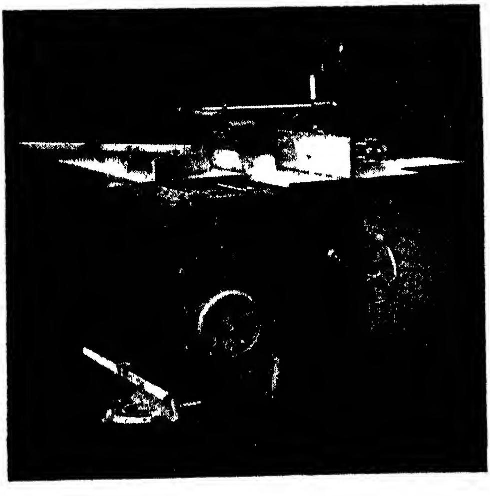


Fig 344

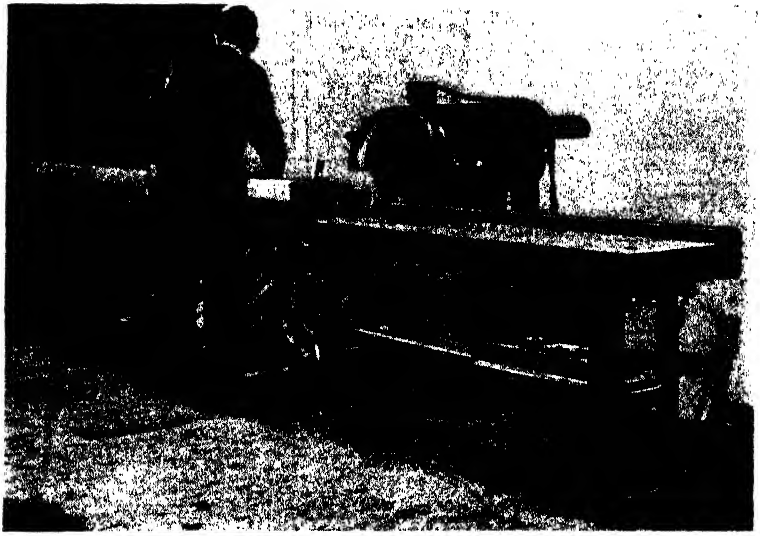


Fig. 545.

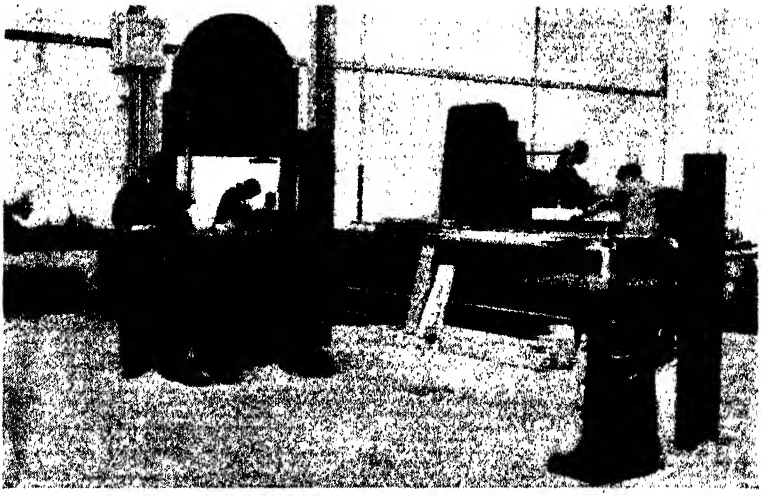


Fig. 546.

The table, the surface of which is accurately ground, is provided with a rise-and-fall movement, controlled by suitable screw located in a convenient position outside.

Although the illustration shows the machine engaged on "ripping" work, by changing the saw it can be converted for cross-cut work, and the table is provided with a groove to take a cross-cutting fence or guide. The table is also fitted with a scale, to facilitate accurate adjustment of the fence.

The ripping fence seen in the illustration is made to swing clear when cross-cutting has to be done, or can be canted to any desired angle up to 45°.

The same firm is responsible for an improved design of cross-cut saw bench, shown in Fig. 544, known as the 18-in. Electric Canting Spindle Dimension Saw.

As the name indicates, the saw spindle is made to cant, while the saw table remains in a horizontal position. In early designs this arrangement was reversed, and the operation of the machine was not without danger. Moreover, long lengths of timber were only handled with difficulty. This revolutionary change not only makes angular cutting very much easier, and safer for the pattern-maker, but also enables him to do his sawing to closer limits of accuracy.

In addition to this canting feature, there are important constructional advantages, such as vertical adjustment provided to the saw, the cross-cut table slides on ball bearings, with adjustment away from the saw to admit grooving saws. Both scales also are provided with graduated scales for the accurate setting of ripping, cross-cutting or mitring fences.

Yet another machine which would certainly be found in the larger pattern shops is the Wadkin 18-Inch Cross-Cutting and Trenching Saw, seen in Fig. 545.

This device is generally located convenient to the timber store, where heavy material can be moved into position, and the saw drawn across it.

Its operation would probably be in the hands of an improver or storekeeper sawyer, who would cut up material to drawings or instructions, ready for the pattern-maker to work upon.

In addition to straight cross-cutting, the saw can be swivelled round for angular cuts up to 45°. A rising and falling motion to the saw is also provided. The utility of the machine is still further enhanced by its ability to do half-lapping and a wide variety of different grooving and trenching jobs.

The sawing equipment of a pattern shop would certainly not be complete without a band saw.

Fig. 546 shows a Wadkin 36-Inch Electrically Driven Band Saw. Although band sawing is light work, it is essential that the machine should have a heavy and rigid body. Vibration will cause saws to break; so will unbalanced or weighty pulleys. In the machine shown, the body is a one-piece casting. The pulleys are of pressed steel, properly balanced and running on ball bearings. The faces of the pulleys are covered with finest rubber vulcanised on. The saw is tensioned by sensitive compression springs, and a tracking device is designed to permit the saw to be tracked while running.

The table can be adjusted for angular cutting, being mounted on a quadrant rather than on a pin, thus avoiding the removal of the packing pieces round the saw. A stop is provided to ensure the table being returned to a dead square position after canting. The saw guides are of a special ball-bearing type to reduce the friction on the back of the saw to a minimum, thus eliminating the risk of saw breakage due to crystallisation of the blade.

Planing Machines.—A small shop might purchase material already planed, but there is little doubt that a machine as seen in Fig. 547 would soon earn its cost. This is a Wadkin Combined Surface Planing and Thicknessing Machine. The special value of this type of machine consists in the additional provision for thicknessing. Here, after one face of the material has been surfaced over the top tables, the trued face is then carried along the lower tables by means of feed rollers and the top rough face is planed by the revolving cutters above.

As the bottom face is parallel with the rollers and the cutter block, the material is thicknessed quite parallel, while the fact that the lower surface has already been trued, and is laid upon the true surface of the bottom table, ensures that there shall be no "winding" of the work after it is delivered at the end of the machine.

The machine shown in Fig. 547 incorporates the latest developments in planer design.

The feed in this machine is by chain drive to the rollers. This method is a great improvement, giving that even and positive feed so essential where uniform finish is desired. The rate of feed can be varied while the machine is in motion, 20, 30, and 46 feet per minute being available.

Both the rollers are of steel, the feeding-*in* roller being grooved and the feeding-*out* roller smooth. A scraper is provided to the feeding-out roller to avoid the possibility of chips being carried round and impressed into the finished surface.

The feed rollers and cutter block are driven by separate motors arranged clear of the machine body, thus remaining comparatively free from chips.

The tables have a horizontal draw-out motion, which is very convenient when changing cutters. Each table has also a rising and falling motion.

The design of the cutter block has received special attention, and is of the circular safety type arranged to give a shearing cut. It is of the two-knife pattern, and so designed that the knives are rigidly supported close up to the edge, thus preventing chatter and making it impossible for the chips to wedge in front of the knives. The cutter block has a cutting circle of 5 inches, and is arranged to take moulding cutters, which can be used without upsetting the ordinary planing knives.

A special feature of this cutter block is the safe method of knife clamping, and the provision of micrometer screws for quick and accurate adjustment.

In addition to straightforward planing and thicknessing, this machine can be adapted to do rebating within certain sizes. The fence, which can be locked at any angle up to 45°, also makes it possible to do any bevelling.

Tongueing and grooving can be carried out by setting the back and front tables dead level, then adjusting the fence to give the correct location of the tongue. After the tongue has been cut, the cutters are changed for the grooving operation.

For moulding work it is merely necessary to clamp the desired cutter on the block, without removing the normal planing blades.

As the surfacing table will drop $\frac{3}{4}$ inches, this can be taken advantage of in planing taper or narrow work.

The machine shown in Fig. 547 can also be had with the front table arranged to cant. This is particularly valuable for the pattern-maker, as the required draught or "strip" on a pattern can be obtained straight from the machine.

Lathes.—The lathe is, of course, indispensable. Saws, planers, etc., can be dispensed with, and often are in small firms, but

not the lathe. At least two lathes are essential, one for light, one for heavy work. In larger shops there will be more.

For light work, lathes of about 5-inch centres, or ranging, say, from 4½ inches to 6 inches, are more useful than any. In all general shops one lathe of from 8-inch to 12-inch centres, dependent on the work chiefly done, will also be required. It is desirable that the beds should be of the extreme length usually manufactured in a given size. The small lathes should have beds of from 5 feet to 6 feet in length, and the larger lathes beds of about 12 feet in length. The reason is that they are then suitable for turning pipes and columns without the necessity of having frequent recourse to the temporary extensions of the beds for that purpose.

Everything should be rigid, massive, and stoutly proportioned. This is necessary to ensure steadiness during turning, and the prevention of vibration and wobbling, which are quite fatal to the performance of accurate work. Often these lathes are bolted, not upon concrete foundations like heavy machine tools but upon floors and joists, and this is another reason why they should possess rigidity in themselves.

Referring to tool rests, the ordinary tee rest is always used for the average run of work. When a long piece of work is being done, then a specially long tee rest can be employed, being supported in two sockets placed from 1 foot 6 inches to 2 feet 6 inches apart. But in a shop where a considerable amount of pipe and column work is done, then it is desirable to have a lathe fitted with a plain slide rest operated by hand, with a plain rack and pinion movement, the tool being held in the tool post in the socket of the rest. For the turning of tapered columns, it is desirable that the poppet or tail stock should be capable of a transverse movement.

For turning face work of large diameter, there used to be two methods usually adopted in the shops. One was to turn the headstock right round on the bed, so that the face-plate revolved at the end of the bed, the other to turn it half round, and run with a twist in the belt. The alteration involved some trouble, and, of course, in a lathe having the headstock cast in one with the bed, was quite impracticable. Since in some shops a large proportion of the work consists of face-plate turning, such as wheels and pulleys, bosses and facings, pipe bends and mouldings, lathes having facilities for this must be included in the equipment.

Fig. 547

Fig. 548 shows a corner of the pattern-making department of Messrs Alfred Herbert, of Coventry, and in the foreground are seen wood-turning lathes by Messrs Wadkin. These are driven by individual motors, and the absence of belting and counter shafts will be noted.

In this particular model, the wide machined surface of the bed is scraped dead true. The tailstock has a long steel poppet controlled by hand-wheel and screw, and the front end is bored the same morse taper as the headstock. The height of the centres is 6 inches. Between centres a length of 2 feet 7 inches can be dealt with, the overall length of the bed being 5 feet. Two speeds are provided, 1,500 and 3,000 revolutions per minute.

A heavier pattern is also available, having cross-slide traversed by rack and pinion, and tailstock adjustable laterally as already described, but an unusually generous gap is provided between the bed and the headstock, allowing for large diameters on the faceplate. The reverse end of the headstock spindle is also fitted with a faceplate, and this, in conjunction with a tee rest moulded upon a tripod casting, makes the lathe a dual purpose machine.

The chucks used by pattern-makers are very simple affairs. They comprise the fork, the bell, and the face chucks, the latter comprising two types; one having a taper screw for some of the smallest jobs, and the other a plain plate, with countersunk holes for wood screws. Generally, an intermediate faceplate of wood is employed between the iron plate and the work.

For the cylindrical work in connection with metal patterns, the engineer's metal turning lathe must, of course, be used, and, unless a considerable amount of metal pattern work is done, the job is passed on to the tool room or machine shop.

Pattern Millers—Years ago the pattern-maker, when engaged upon core-box work, had to be more of a wood sculptor, and it is not surprising that enterprising designers of equipment turned their attentions to the production of a suitable machine to simplify this work. Messrs Wadkin, of Leicester, produced their Mechanical Wood Worker in 1897, and since then they have made frequent improvements, until to-day there are available several types of their Universal Pattern Miller, two of which are shown in Figs. 549 and 550.

Fig. 548.

What is described as the Junior Model WS (Fig. 549) is suitable for the smaller shop, whose work may not justify the installation of a larger model.

The following details will be found to apply to both sizes of machine.

The overhanging arm carrying the spindle head is mounted on sliding ways on the main frame, and can be raised and lowered either by power or hand-feed. The power motion is obtained by a motor built on the end of the arm, driving on to the raising and lowering screw by gears. Hand-motion is by hand-wheel placed immediately over the spindle head.

The spindle head carried by the overhanging arm swivels between the vertical and the horizontal in either direction. The principal angles are indexed, and located by a spring plunger taper pin engaging with suitable holes. Intermediate angles are secured by a convenient locking handle.

The cutter spindle is provided with a movement at right angles to the arm, controlled by a lever handle. It is arranged with a spring plunger to give definite depths of feed, also with limit stops. In addition, a fine screw feed is provided.

The spindle carries a chuck forged solid with the spindle. It is bored for No. 5 Morse taper, and carries a set-screw for securing the tool holders and cutters. The spindle runs in heavy ball bearings, and the thrust is also taken by ball bearings.

The cutter spindle is driven by a motor built directly on to the end of the arm, and coupled to the main driving shaft inside the arm. It is of the change pole type, giving four speeds to the spindle.

Motors for both the spindle and the rise and fall of the arm are controlled by a single lever handle on a control station mounted on the end of the arm, which gives start, reverse, and stop for the spindle, also rise and fall for the arm. The main contactor panel is housed inside the main frame of the machine together with a speed selector switch for varying the speed of the motor.

The cutter spindle is driven by special machine-cut spiral gears with ground teeth and running with the utmost smoothness, silence, and absence of vibration. These gears are totally enclosed and arranged to run in grease.

This method of driving allows the cutters to be carried close to the bearings and to dispense with long boring bars. It also

enables the spindle to be put in any angular position, which often saves recutting the work and increases the range of the cutters.

The work table has two motions at right angles, operated by screw and hand wheel. The table also has a rotary movement, for dealing with all kinds of circular and radius work. A hand lever is fitted with a spring plunger taper pin giving all the principal angles.

The table is graduated and the centre recessed so that cutters may be lowered below the surface of the table. The combined table motions can be read direct from contraction or standard rules. Suitable spring and dead stops are fitted to the various table movements.

The table body frame upon which the compound slides are mounted is provided with a secondary rotary motion. This enables the work table and slides to be turned to any desired angle, and frequently dispenses with resetting the work. The principal angles are located by a spring plunger, and any intermediate angles may be secured by locking handle.

In the larger model the complete table body is mounted on anti-friction rollers and travels along the foundation frame rails. This movement is controlled by means of a conveniently placed hand wheel and a quick-acting lever locks the table in any desired position.

A wide range of accessories are supplied with these machines, and a small idea of the diversity of operations possible can be gained by a glance at the work on the machine in Figs. 549 and 550. By the addition of an indexing head, which can be mounted upon the work table, gears, and worms of any desired pitch can also be produced.

Boring.—Hole boring, an inaccurate and lengthy job when carried out with a brace and bit, can be expeditiously handled in the manner shown in Fig. 551. This machine by Messrs Wadkin is electrically driven, and can be operated by hand lever or foot pedal.

Depth can be controlled by the manipulation of an adjustable stop. The height of the table is altered by means of the hand wheel seen in the foreground.

The chuck for holding the various bits is of the keyless self-centring pattern, and holes up to 1 inch diameter and 6 inches deep are conveniently dealt with.

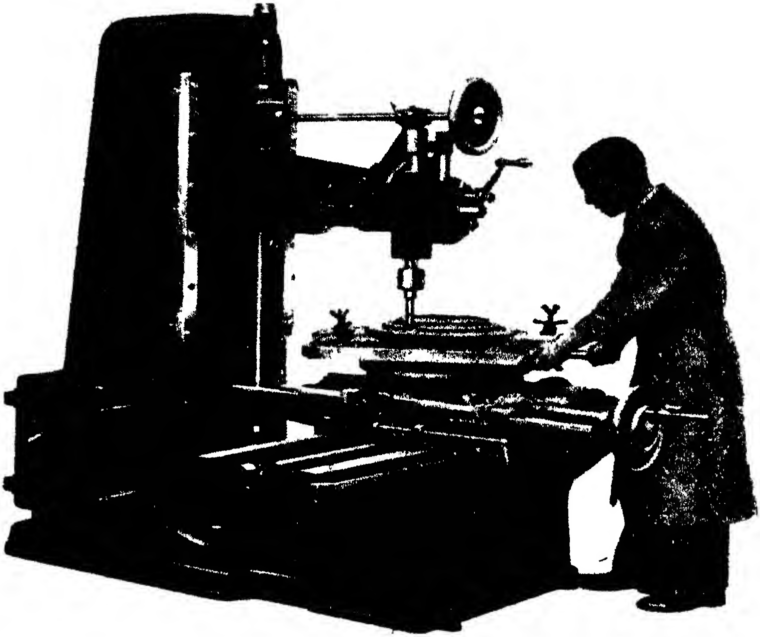


Fig. 550.

Sanding Machines.—The amount of time saved by the use of a sanding machine for finishing woodwork will only be fully appreciated by one who has carried out such work by hand. Even a metal disc with a glass-paper covered surface, gripped in an ordinary lathe chuck, is better than nothing, but the 30-inch combined Disc and Bobbin Sanding Machine shown in Fig. 552 represents the last word on this subject. The picture demonstrates the use of the disc and bobbin spindles respectively.

Both can be operated at the same time, and as tapered formations are common in pattern work, the machine tables are arranged to cant to any desired angle.

This class of machine is fitted with ball bearings throughout, and the drive to the bobbin incorporates a reciprocating motion.

The machine is available driven by belt or electric motor.

The bobbin sanding arrangement is a more recent development, and is a remarkable labour-saver. The bobbin is of a special split type. It is made in two halves with a unique screw method of locking which both stretches and holds the abrasive paper. With this pattern bobbin the paper can be renewed in ten seconds, without the use of glue or tacks.

Two spare discs and a press are supplied, so that directly one is worn out another is ready to replace it.

The reciprocating motion applied to the bobbin gives a smoother finish to the work and also by this means an unworn portion of the bobbin can be brought in to use.

Dust Extractors.—Intelligence suggests, and the Home Office demands, that every woodworking department should be fitted with suitable means of removing dust.

The sanders are, of course, the worst offenders, and these are generally grouped away from benches and other machines, so that they can be more effectively dealt with.

In Fig. 552 the suction end of an extractor can be seen lying between the disc and the bobbin, and in most cases the piping which conveys the dust from various points is carried overhead and delivered outside to a convenient place.

Tool Grinding.—This question is often dismissed in a very perfunctory manner, the point that money can be saved by efficient tool grinding being overlooked.

A skilled man with a full knowledge of the requirements of the various tools will get good results from an indifferent grinding wheel, but an intelligent management will see that

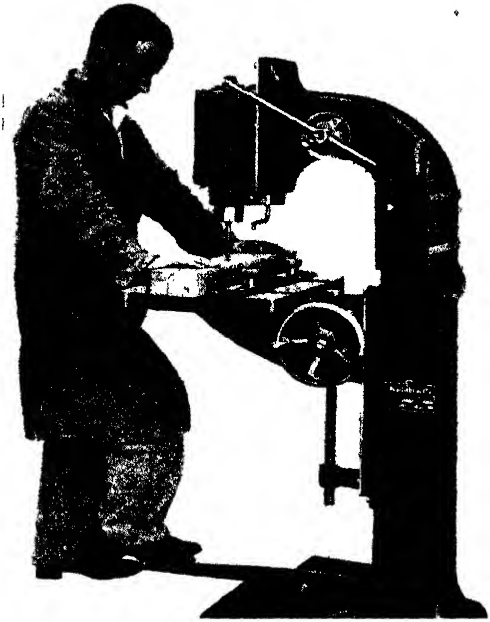


Fig. 551

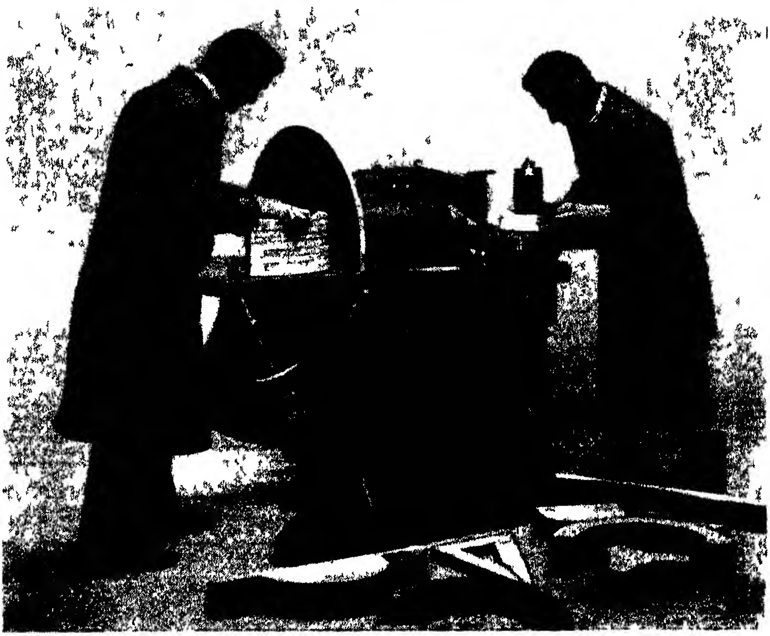


Fig. 552.

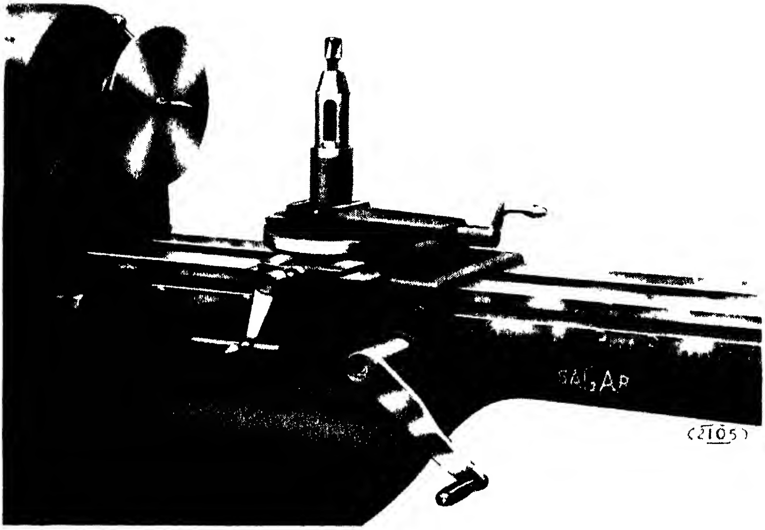


PLATE IX.—Compound slide rest for wood turning.

Courtesy Sagar & Co., Halifax.

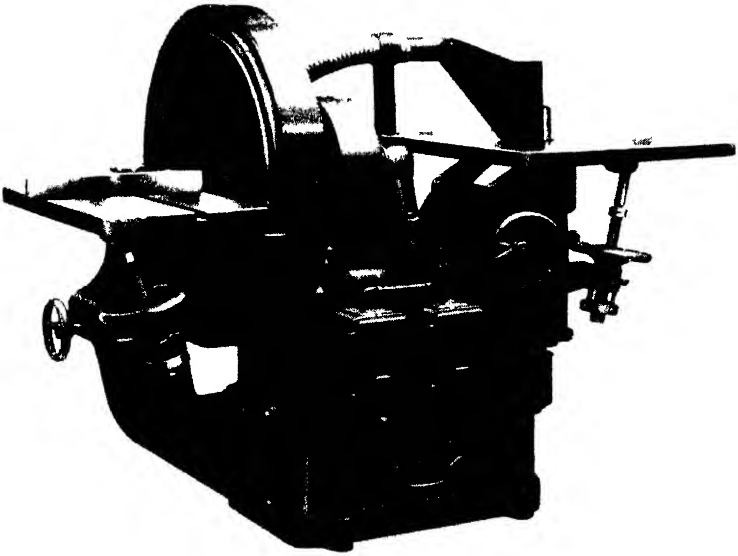


PLATE X.—The latest in disc and bobbin sanders. Note the provision for dust extraction, a very important point.

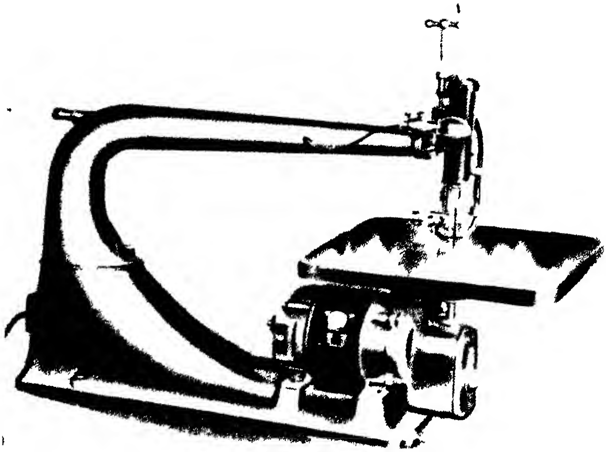


PLATE XI.—24 in. direct drive jig saw.

For small work the machine shown has proved of value. The ball handle seen at the top of the blade holding gear enables tension to be applied while the machine is running.

Courtesy Walker Turner Co., New Jersey, U.S.A.

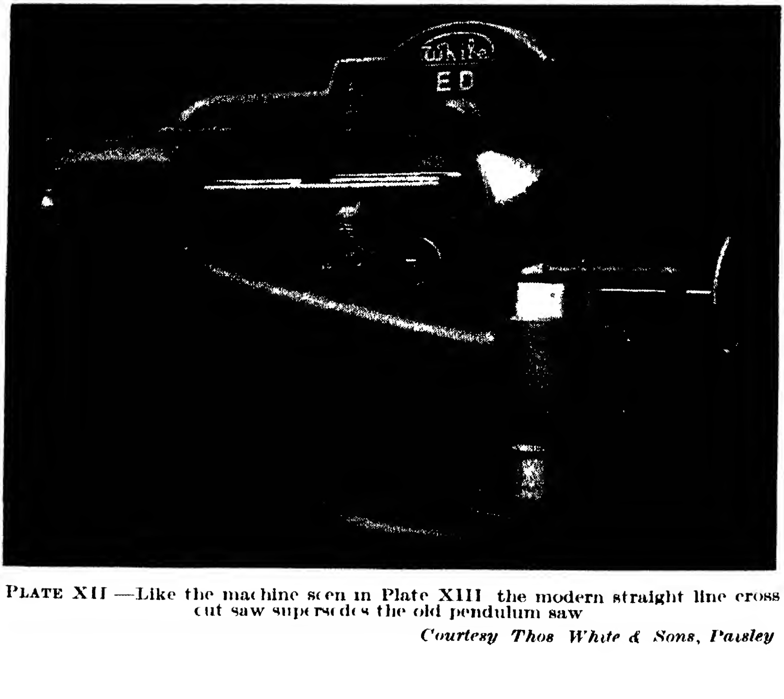


PLATE XII.—Like the machine seen in Plate XIII the modern straight line cross cut saw supersedes the old pendulum saw.

Courtesy Thos. White & Sons, Paisley.

PLATE XIII.

This is a very popular American machine and is specially designed to ensure straight line work. The saw assembly can be tilted 45 degrees about a point. The carriage is returned by means of coiled springs thus reducing the effort. An interesting feature is the spring loaded cone centre which enables saws having holes $1\frac{1}{8}$ to $1\frac{1}{2}$ in. diameters to be centred automatically before clamping.

Courtesy, Messrs Fay & Egan, Cincinnati, Ohio, U.S.A.

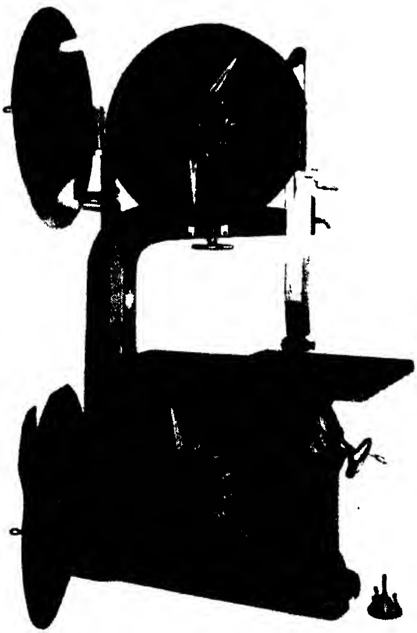


PLATE XIV.

A 36-in. band saw is seen here and, with Plate XV., illustrates the modern tendency to have machines neat and attractive as well as efficient. This machine is fitted with a patent straining device seen to the right of the upper wheel which automatically provides yield when wood dust or occasional slivers of wood get trapped between saw and wheel.

Courtesy, Messrs Fay & Egan, Cincinnati, Ohio, U.S.A.

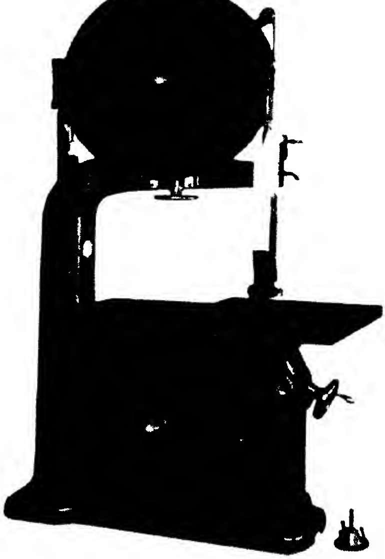


PLATE XV.—Showing the machine illustrated in Plate XIV with its wheel doors closed and ready for operation.

Courtesy Fay & Egan, Cincinnati, Ohio, U.S.A.

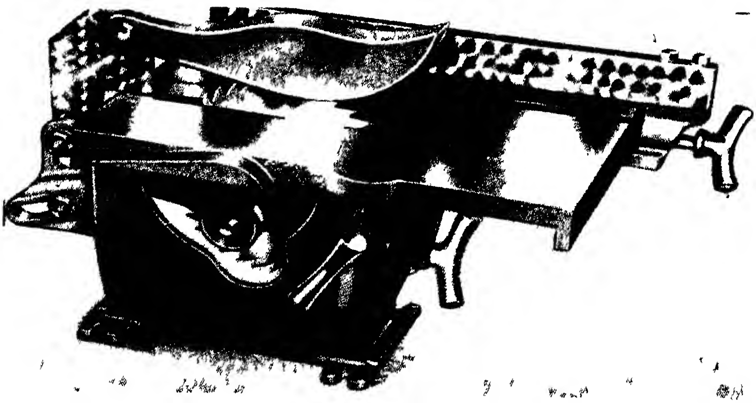


PLATE XVI.—A useful 7 in. circular saw. The spindle is adjustable for height while the table is fixed.

Courtesy, Walker Turner Co., New Jersey, U.S.A.

To face page 353

no risks are taken. There are a large number of tool grinders on the market, but few have been designed with the user's special requirements in mind. Messrs Wadkin, however, supply one admirably adapted for the pattern-making department.

On one pedestal located in a tray are a rough and fine oilstone running at 200 revolutions per minute. On another spindle are arranged an emery wheel, a leather stropping wheel, and a cone-shaped wheel for grinding gouges, &c. Both spindles are mounted on ball bearings, and suitable guides and rests are provided so that apart from joiner's hand tools, planing-machine irons, trimming knives, moulding cutters, &c., can be easily dealt with.

All tools leave the machine hollow-ground, and a special internal oiling system prevents tools from being scrapped due to overheating.

Speeds.—Opinions on correct speeds vary, and allowance must be made for any work of an unusual character. Some idea, however, may be gained from the following: Wood-turning lathes, 400 to 4,000 revolutions per minute; circular saws, 8,000 to 10,000 feet per minute; band saws, 4,500 to 5,500 feet per minute. Planer blades should make about 4,000 revolutions per minute.

An emery wheel of 8 inches diameter should run at about 3,000 revolutions per minute. In the case of any grinding wheels, it is best to rely entirely upon the speed indicated on the tag supplied with the wheel, as it is extremely dangerous to run them too fast. If, on the other hand, they are run too slow, they quickly wear away.

Accessories.—Under this heading is included an old, yet still useful, machine, the Universal Trimmer (Fig. 553). It is hand operated, and will cut any ends within its capacity, both square and bevelled, and all bevels, besides mitres. An end, that would take ten or fifteen minutes to square with chisel and plane, can be done more accurately in this machine in a less number of seconds. The gauges or guide brackets at the ends of the machine, which are quickly adjustable to lines scribed on the planed base, become the guides for bevel cutting in one direction, while the true adjustment of the faces of the knives at right angles with the face of the planed base ensures square cutting in the other direction.

The two knives are screwed to a plate which is guided in

grooves planed in the base of the machine, and in the top cross-bar, and are actuated by a hand lever and pinion working in racks above and below. To prevent accidental cutting of the hands by the acute corners of the knives when they project beyond the ends of the machine, guard wings of iron are screwed to the end of the machine.

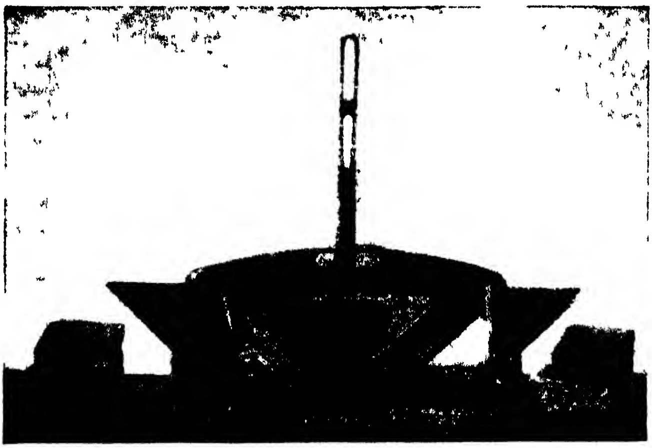


Fig. 553.

There are also to be found a variety of gluing clamps, some of very ingenious design, developed as a result of special requirements. Where a large number of wood screws are to be used, the automatic screw-driver will be found even quicker than the driver blade in the joiner's brace.

Difficulty is often experienced in holding awkward pieces while being worked upon by hand, and Messrs Wadkin have developed a bench vice with this in mind. It really embodies six vices. It has one pair of jaws 18 inches wide, two pairs 7 inches wide, one pair 3 inches wide, and two pairs of dogs to hold circles and segments. The vice will swivel to various positions, and grip tapered pieces without difficulty. The locking mechanism is quick-acting and slip-proof.

CHAPTER XXX.

ESTIMATING WEIGHTS OF CASTINGS FROM THEIR PATTERNS.

Reducing to Feet and Inches.—Multipliers.—Sources of Error.—Specific Gravities.—Practical Example in Calculation.—Approximate Formula.—Bevel-wheels.—Mortise-wheels.—Pipes and Columns.—Decimals.—Useful Notes.

THE pattern-maker is often required to estimate the weight of a casting with more or less of accuracy, that accuracy being demanded either on account of the value of the metal, or by reason of the purpose for which the casting is intended. Accuracy within a hundredweight or two may be sufficient in some large castings, while in other cases, and in smaller castings, we may wish to be correct within a pound or two. Let us go a little into detail in this matter.

To calculate the weight of a casting, it is necessary to ascertain the number of cubic feet, or cubic inches, it contains, and to convert that number into weight by a multiplier. These multipliers vary, of course, with the nature of the metal to be employed. Thus, we know that a cubic foot of cast iron weighs on an average 450 lb., and a cubic inch ·263 lb. These, then, are the multipliers by which cubic feet and cubic inches respectively of that metal are converted into pounds. Another multiplier easily remembered and commonly used is the number of pounds contained in a square foot of iron 1 inch thick. Such a plate weighs 38 lb. Gunmetal, again, would require another multiplier; a cubic inch would weigh ·3 lb. Lead, steel, copper, and every other metal would appropriate its own multiplier. Hence the general rule is:—**Ascertain first the number of cubic inches (or feet) contained in the pattern; treat this total with its appropriate multiplier: the quotient is the number of pounds which the casting may be expected to contain.**

I use the word "expected" designedly, for it often happens that a most careful calculation is rendered very wide of the mark through contingencies lying beyond the control of the pattern-maker. I have had a difficult gunmetal casting, weighing 284 lbs., vary only 8 lbs. from the estimated weight, and an iron casting of 5 tons within 2 cwt.; and I have also, on the other hand, been a couple of hundredweights wide of the mark in castings ranging between one and two tons. There are many causes at work to produce such discrepancies. There is the custom of "rapping," which will make an appreciable difference in small work. There are different densities of metal, which will cause variations in the weight of large castings. A mould rammed unequally—that is, harder and softer in different parts—will allow a casting to swell, and to come out larger in the imperfectly made parts than the pattern. A large plate will increase in thickness, and therefore in weight. A broken mould will not always be mended up just like the pattern. These and many other things go to destroy the accuracy of a calculation; but we have to take things as they are, and frequently, judging by past experiences, we can make slight allowances for these and other contingencies, and thus produce, on the whole, very reliable results.

I spoke of the necessity for reducing to feet or inches, but there are other methods in favour with workmen. One of these is the method of specific gravities. The pattern is steadily immersed in water in a tank, the displaced water is allowed to overflow into a second vessel, and is then weighed. This, the weight of water displaced by the pattern, is multiplied by the sp. gr. of the metal in which it is to be cast, and the quotient equals the weight of the casting required. Thus, supposing a pattern displaced $4\frac{1}{4}$ lbs. of water, and that the sp. gr. of average cast iron be taken at 7·3, we shall get—

$$4{\cdot}25 \times 7{\cdot}3 = 31 \text{ lbs.} = \text{weight of casting.}$$

This is a very accurate way, presuming that a proper vessel is available by which no waste of overflow water occurs; but as it needs some special apparatus, it is hardly suitable for large patterns, and is seldom resorted to except in those cases where accurate weight is of the utmost importance.

Another and a most delusive method is to weigh the pattern itself, and multiply that by 16, which is supposed to represent the relative weights of dry yellow pine and cast iron. This leaves out of consideration the various densities of different qualities of pine, and the presence of screws, nails, or other

foreign substances in the pattern. We simply mention this by the way, and pass on to illustrate the method we alluded to in the first place.

Let us take, as a practical example of the method of calculating by cubic inches, the cog-wheel in Fig. 554. This

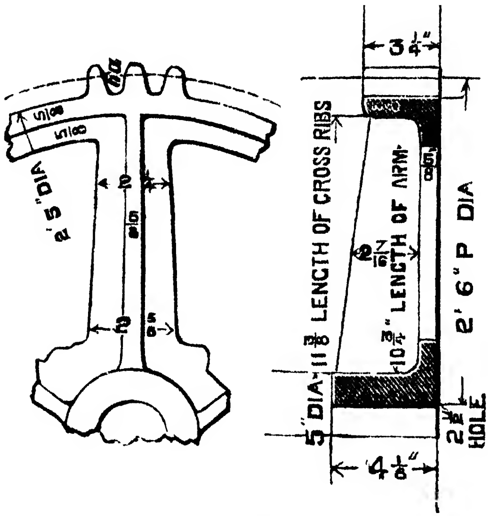


Fig. 554.

is a small casting, so we must reduce to inches, feet being too large a factor.

First of all then, take the rim. Its outer diameter is 2 feet 5 inches, its thickness $\frac{5}{8}$ inch, the average or mean diameter, therefore, being 2 feet $4\frac{3}{8}$ inches. To save the labour of calculation, we turn to a table of circumferences, and find that the circumference of such a ring is 89 inches; therefore, imagining the rim unrolled, it becomes—

$$1 \text{ strip } 89 \text{ in.} \times 3\tfrac{1}{4} \text{ in.} \times \tfrac{5}{8} \text{ in.} = 180{\cdot}6 \text{ cubic inches.}$$

Then the teeth. Imagine all the points of the teeth, *a*, broken off along the pitch-line and inserted between the roots, *b*. We see that a continuous ring is formed (neglecting the slight allowance for clearance). The mean diameter of this ring will then be taken, and its circumference deduced. At 2 feet $5\frac{5}{8}$ inches average diameter, it is

1 strip 92 in. × $3\frac{1}{4}$ × $\frac{7}{16}$ = 130 cubic inches.

The boss in like manner may be imagined to be a simple ring piercing the arms, and can be reckoned thus:

One solid cylinder 5 inches diameter × $4\frac{1}{8}$ long — one cylinder (the hole) $2\frac{1}{2}$ inches diameter × $4\frac{1}{8}$ long. A disc of 5 inches diameter by 1 inch thick will be found, on referring to a table of areas, to contain 19·6 cubic inches; one $2\frac{1}{2}$ inches diameter by 1 inch thick will contain 4·9 cubic inches. Subtract the one from the other, and multiply by $4\frac{1}{8}$; the quotient is the number of cubic inches in the boss.

19·6 — 4·9 × $4\frac{1}{8}$ = 60·2 cubic inches.

The rib or flange within the rim will, at $\frac{5}{8}$ wide, average 2 feet $3\frac{1}{8}$ inches in diameter Then it will contain—

85·2 × $\frac{5}{8}$ × $\frac{5}{8}$ = 33·3 cubic inches.

There will be six arms extending from boss to rim, averaging $2\frac{7}{16}$ in width. Therefore we have—

Six pieces $10\frac{3}{4}$ × $2\frac{7}{16}$ × $\frac{5}{8}$ in. = 97·2 cubic inches

Feathers or cross-ribs likewise—

Six pieces $11\frac{3}{8}$ × $2\frac{4}{8}$ × $\frac{5}{8}$ = 109·8 cubic inches.

Hollows add so little to the weight of a casting that they are generally taken no account of, or something else is set off against them. If the weight is desired so very precisely, they can be reduced to triangles, and the triangles in turn to rectangles.

These totals of cubic inches should now be added together, and multiplied by ·263, which will give the weight of the wheel in lbs.

Reckoning out, we find that there will be 161 lb. weight of cast iron in this wheel.

There are rules given in various books for calculating the weights of wheel castings by their diameter and pitch. They are principally useful where approximate weights are desired, or where wheels are made by the same rules from which these formulæ are deduced. Three such rules given by three different authorities yield the following results in the wheel we have been considering. It contains—

75 teeth of $1\frac{1}{4}$-inch pitch, and is $3\frac{1}{4}$ inches wide, and 2 feet 6 inches diameter.

Formula from	D. K. Clark,	170 lb.
,, ,,	Unwin,	171 lb.
,, ,,	Box,	158·4 lb.*

In a wheel weighing several cwts. the difference would be more marked. The ring of a bevel-wheel might appear at first sight to offer a difficulty in the way of calculation, its diameter varying at every point. But if we take average diameter and average thickness, it will be just the same as though we divided it into an infinite number of sections, and reckoning each separately added their totals together afterwards.

The recesses in a mortise-wheel will not complicate the matter in the least, for after finding the number of cubic inches in the ring, on the assumption that it is solid throughout, we need then only find the number of cubic inches in each mortise, multiply that by the number of mortises, and subtract the sum total from the number of inches in the solid ring.

A more intricate piece of work, such as a steam cylinder, with passage and perhaps jacket cores, with webs of metal of odd shapes, curved brackets and feet, and such like, should be divided out piecemeal on the drawing itself in order to get

* They are the following :—

$W = (\cdot05 + \cdot08\,p)\,d\,(1 + 0\cdot10\,d).$
d = diameter in feet.
p = pitch in inches.
$\cdot05$ = constant.
W = weight per inch of breadth.

Bevel wheels to be taken at $\frac{3}{4}$ to $\frac{4}{5}$ the weight of spur ones.
—(D. K. Clark, "Rules, Tables, and Data," p. 741, edit. 1878.)

$W = K\,N\,b\,p^2.$
p = pitch.
b = breadth of face.
N = number of teeth.
K = 0·38 for spur wheels, 0·325 for bevels.
—(Unwin, "Machine Design," p. 302, sixth edition.)

$W = (D \times P \times W) + (\sqrt{D \times P \times W}) \times M.$
$D = p$ diameter in feet.
P = pitch in inches.
W = width on face in inches.
M = 12 for spur wheels, 10 for bevels.
W = weight in lbs.
—(Box, "Mill Gearing," p. 24.)

exact dimensions. Without this precaution we are likely to reckon some portions twice over, or to omit some parts altogether. In reckoning, it should be our aim to simplify matters as far as possible by reducing everything to *circular* or *rectangular* form.

The weight of parallel pipes and columns may be obtained from tables, either by tables of weights for pipes of various thicknesses, or by a table of solid cylinders. Thus—tables are given in all engineers' books of reference of the weight of solid cylinders a foot long.* All we have to do, then, is to take the weight of a cylinder equivalent to the *outer* diameter of our pipe, and subtract from that the weight of one equal in diameter to the *bore* of the pipe. Or if such tables are not at hand we can get the *average* diameter, thence obtain the circumference, and multiply that by the *length* of the pipe and its *thickness*. In a taper column we must take the *average* diameter, and reckon then as though it were parallel.†

If we have a column with a quantity of mouldings and ornamental work, where it would be impossible to strike an average, we must divide into *sectional lengths*, calculate each separately, and adding their totals together, thence deduce the weight.

If a casting weighs several cwts., it is inconvenient to have a sum total in lbs. The multiplier ·009 will convert lbs. into cwts.

In the calculation of weights I find decimals more convenient than vulgar fractions, and inches more convenient than feet. Thus it is easier to multiply—

$$11{\cdot}87 \text{ inches} \times 6{\cdot}75 \text{ inches} \times 4{\cdot}62 \text{ inches}$$

than to multiply

$$11\tfrac{7}{8} \text{ inches} \times 6\tfrac{3}{4} \text{ inches} \times 4\tfrac{5}{8} \text{ inches},$$

and to multiply

$$69{\cdot}75 \text{ inches} \times 14{\cdot}37 \text{ inches}$$

than

$$5 \text{ feet } 9\tfrac{3}{4} \text{ inches} \times 1 \text{ foot } 2\tfrac{3}{8} \text{ inches}.$$

* See Table in Appendix, p. 378

† A correct rule for finding the weight of a lineal foot of pipe in lbs is this:

$$W = K\,(D^2 - d^2).$$

W = weight of a lineal foot in lbs.
D = outside diameter of pipe in inches.
d = inside " " "
K = a multiplier 2·45 for cast iron.
2·82 for brass

We have assumed that tables of areas and circumferences are always ready to hand—as they are in the workshop. But when a man is sent out to take dimensions for a casting, it sometimes happens that an approximate weight is required at the same time. It is well, therefore, to bear in mind that—

$$\text{Diameter}^2 \times \cdot 7854 = \text{area}$$
$$\text{Diameter} \times 3{\cdot}14159 = \text{circumference},$$

Or,

$$7 : 22 :: \text{diameter} : \text{circumference},$$

and that cubic inches divided by 4 = pounds, nearly

MULTIPLIERS FOR THE COMMON METALS.

Cubic inches ×	·263	=	lb.	cast iron
,, ,, ,,	288	=	,,	steel
,, ,, ,,	·3	=	,,	brass
,, ,, ,,	·41	=	,,	lead
,, ,, ,,	·32	=	,,	copper
,, ,, ,,	·266	=	,,	tin.

See also Appendix for useful and more extended tables.

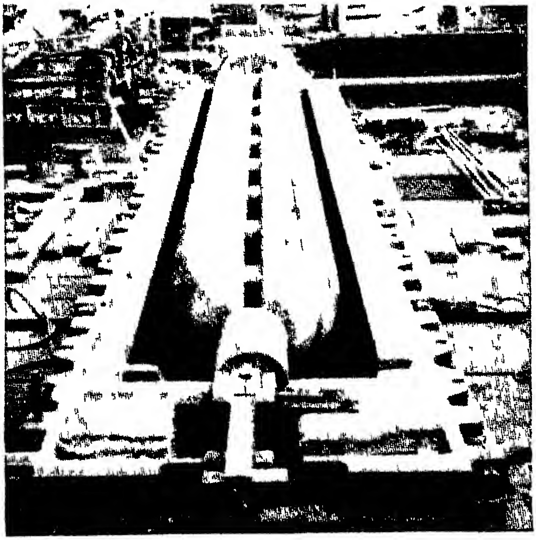


Fig 554A

Finished Bottom Half Mould and Core (see pp. 169 and 367).

Courtesy, International Meehanite Metal Co. Ltd., London

CHAPTER XXXI.

THE STORAGE OF PATTERNS.

Storage in Sets.—Or by Classes of Work.—Shelving.—Registration.

STANDARD patterns are rather expensive articles, and since they are worth making well, proper care should be taken of them. Many matters conduce to their due preservation. The chief one of course is the manner in which they have been made, and the quality of the timber used in their construction,—matters which need not be dwelt upon here. We assume that care is taken in regard to these, and that the problem is how to preserve such patterns for as great a length of time as possible in useful service.

They must be stored in a properly ventilated building. If they are just underneath hot tiles in the summer, the timber will warp and shrink badly. If kept under open sheds out of doors, they will suffer from snow and rain.

To counteract the effects of frequent swabbing in the foundry, the patterns must be treated with occasional applications of varnish, repeated as often as portions of their surfaces become roughened up. Damaged parts should not be allowed to go very badly, but ought to be renewed, and also any incipient cracks, or loosening of joints, must receive attention. In the preservation of patterns, as in other things, prevention is better than cure, and a stitch in time saves nine.

Proper storage of patterns involves something more than bundling them indiscriminately into a building. There are two systems of storage, two ways of arranging them in the stores. In one, all patterns belonging to one job are grouped together; in the other, the heavier, and the lighter patterns

are kept in separate places, or patterns of a class are stored with other patterns of that class. There are advantages and drawbacks to each system, but the three main controlling factors are the bulk of the patterns, the material of which they are made, and the character of the work done, whether standard, or miscellaneous and jobbing.

With regard to the dimensions of patterns, there are few stores so happily situated as to have the patterns contained wholly on a ground floor, but most consist of two or more stories, on the upper floors of which it is impossible to get heavy patterns. Hence the general arrangement is to put bulky and heavy patterns on ground floors, and those of medium and small dimensions on the upper ones. There is not much disadvantage in this if a proper register is kept of the location of patterns.

With reference to the storage of patterns in sets *versus* storing them according to their class, both systems are usually adopted in shops—the first for absolutely standard work, the second for that of a miscellaneous character. There are great advantages in storing patterns for standard work separately from class work. Thus, if there is a set of patterns for an engine, or a set of pumps, or a crane, it facilitates the carrying through of work if these are kept apart from everything else, the heavy beds perhaps alone excepted. First, the patterns can at any time be taken from the stores *en masse*, and sent directly into the foundry, without the trouble of having to look them up in separate locations. Another advantage is that as such patterns are not altered to be used for miscellaneous orders, they need not be checked over carefully by the drawings before being sent into the foundry, as must be done when they are so used.

On the other hand, to store patterns by their classes has much to recommend it in shops that deal mostly with general and jobbing work. It seems right and natural to put all wheels and pinions together in one location, all engine cylinders in another, valves in another, glands in another, and so on. By this method the making of new patterns is often avoided, because something can be found in the stores that can be used with or without alteration. But this is done at a corresponding inconvenience, for it means that when sets of work have to be made up from the miscellaneous collections scattered about the stores, some considerable time is occupied in hunting up the separate parts, and then every pattern has to be checked carefully by the drawings as a safeguard.

because the chances are that several of the patterns have been altered for other jobs. Nothing can be taken on trust in such a system, except at the risk of making serious blunders. From this point of view it is more economical to retain standard patterns for standard use only, to be kept with their work, and never altered for any other job, and never used for any other, except they are used absolutely unaltered. Alteration when made is often forgotten, and when the patterns are wanted again they are assumed to be correct, and so blunders are made.

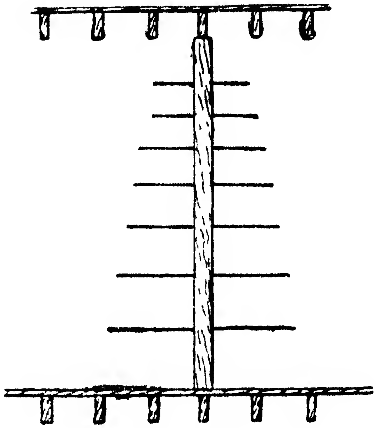


Fig. 555.

For metal patterns it is usual to provide a separate stores on the ground floor, and plated patterns, for plate and machine moulding, are also usually kept separate from all others; but in the case of standard work, these also may be kept with their sets. The choice of these various methods must, however, be largely governed by the frequency of orders. When a set of work is wanted but seldom, it is hardly worth while keeping it absolutely distinct from everything else, and then the arrangement according to classes is preferable. But when the sets are often wanted, the separate system is the most economical. Between these extremes the judgment of the foreman must decide what is best to be done.

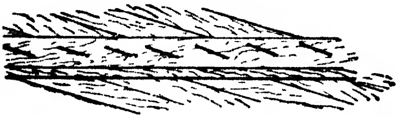


Fig. 556.

In arranging patterns in stores different methods are adopted. The following are the best for an average range of work:—Remembering that one great point in planning a stores is to have everything visible and get-at-able. Shelves and racks must not be too deep, and avenues must be provided sufficiently wide to carry patterns along.

On the ground floor wooden posts are fixed at intervals to form supports for rails or iron bars, against which heavy

patterns will be stood edgewise. This is better than piling patterns vertically, which involves lifting off the top ones to get at the lower ones.

Pipe and column patterns may be laid horizontally on iron bars (Fig. 555) that pass through the posts. Alternatively they may be stood on end at a slight angle, or perpendicularly if a hook is provided at the top to keep them from falling down.

Many patterns, as trolley wheels, wheel centres, pulleys, may, when ground floor area is limited, be hung with tar twine from rods (Fig. 556) driven into the joists beneath the floors. On the upper floor or floors shelving is best built in the manner shown in Figs. 557 or 558, and sets of patterns are parted off on these with movable strips. The larger patterns go on the floor and smaller ones on the shelves. It is best to put, as far as possible, only those on the upper shelves that are seldom wanted, keeping those in frequent use on the lower ones, where they are readily seen. Very small patterns are kept together best in shallow wooden boxes, of which large numbers may be utilised.

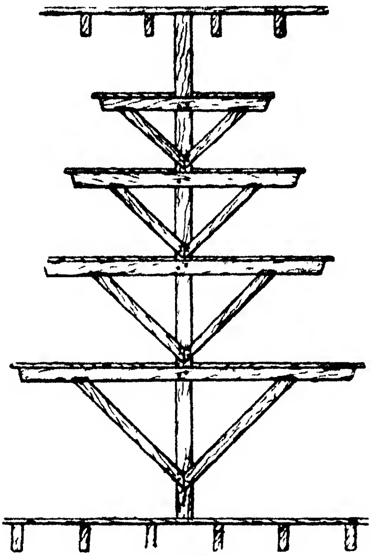


Fig. 557.

In classifying gear wheels, patterns should be kept distinct from toothed blocks and core boxes for machine service. The pinion patterns again must be separated from wheels. These are each grouped according to pitch on the shelves, beginning at the finest, and arranged progressively to the coarsest. In machine wheels it is better not to separate pinions and wheels, but to arrange by pitches simply. Both in patterns and blocks, classes of wheels must have distinct locations, spurs, bevels, worms, worm wheels being kept separate. Any wheel patterns that are not standard, but which have been made to match existing wheels, and bastard bevels, should be kept away from the standard

work, and their particulars clearly stamped on patterns and blocks.

Unless order is observed in the storage of patterns they become unmanageable in time, and some cannot be found when wanted. The difficulty increases in proportion to the alterations made. Hence the value of a register sheet like that shown below:—

Pattern No.	Name	Drawing No.	Iron	Gun-Metal	Weight	Remarks	Shelf
					Tons. Cwts Qrs Lbs.		
10464	Bedplate	6402	1		2 3 0 18	5 Core-Boxes	25
10465	Standard	6403	2		18	1 Core-Box	25

A "pattern number" is stamped upon every pattern, every loose piece, and every core-box belonging to that pattern, so that the parts are readily assembled when they are returned from the foundry. The name of the pattern is entered in the register book, but is not usually stamped on the pattern itself. The "drawing number" indicates the particular drawing from which the pattern has been constructed. "Iron" and "gun-metal" indicate the metal in which the pattern is cast. and under one or the other the number of castings off per set is marked. If other alloys are used, as steel, phosphor bronze, etc., these are written under one of these columns. Under "Weight," the weight of each casting is entered. Under "Remarks," any information of value is inserted, as number of core-boxes, notes about alterations, &c. The entry under "Shelf" indicates the location of the pattern in the stores. The pattern register should be a book of 1,000 pages, and as the volumes become filled they are kept for reference.

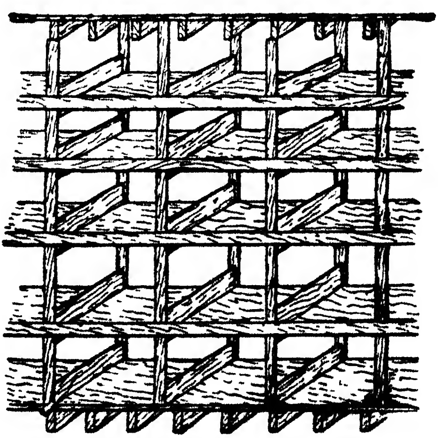


Fig. 558.

When patterns come from the foundry their

various parts and core boxes should be assembled by the man in charge of the stores, and any necessity for repairs or replacements be notified to the foreman. When possible the patterns should be put together complete and ready for service before being stored.

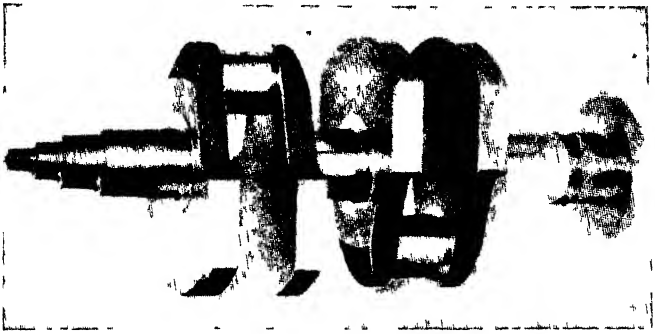


Fig. 558A

Cast-iron Crank Shaft with Cored Journals.

Courtesy, International Meehanite Metal Co. Ltd., London.

High-test Cast Iron.—Until recent years such items as crank shafts were made from forged steel, but the pattern-maker will do well to note the progress made in the metallurgy of cast iron. Several grades of what is described as high-test cast iron have been produced under the name of "Meehanite" from which designers can make a selection. Apart from other remarkable features, an X-ray examination of a casting will reveal an entire absence of flaws or blow holes. The simple crank shaft illustrated, has, under test, proved quite equal to any steel forging and, moreover, having its journals cored, except at the webs, no expensive oil holes have to be drilled. The pattern for these shafts are made in two halves, dowelled together. It would appear that while a certain amount of smaller cast work has been replaced by plastic moulding in bakelite, etc., it will be certainly made up by castings which were previously made from steel forgings.

APPENDIX.

TABLE OF DIAMETERS, CIRCUMFERENCES, AND AREAS OF CIRCLES.

Diameter.	Circumference.	Area.	Diameter.	Circumference.	Area
⅛	·3927	·01227	3¼	10·210	8·2957
¼	·7854	·04909	3⅜	10·602	8·9462
⅜	1·1781	·1104	3½	10·995	9·6211
½	1·5708	·1963	3⅝	11·388	10·320
⅝	1·9635	·3068	3¾	11·781	11·044
¾	2·3562	·4417	3⅞	12·173	11·793
⅞	2·7489	·6013	4	12·566	12·566
1	3·1416	·7854	4⅛	12·959	13·364
1⅛	3·5343	·9940	4¼	13·351	14·186
1¼	3·9270	1·2271	4⅜	13·744	15·033
1⅜	4·3197	1·4848	4½	14·137	15·904
1½	4·7124	1·7671	4⅝	14·529	16·800
1⅝	5·1051	2·0739	4¾	14·922	17·720
1¾	5·4978	2·4052	4⅞	15·315	18·665
1⅞	5·8905	2·7611	5	15·708	19·635
2	6·2832	3·1416	5⅛	16·100	20·629
2⅛	6·6759	3·5465	5¼	16·493	21·647
2¼	7·0686	3·9760	5⅜	16·886	22·690
2⅜	7·4613	4·4302	5½	17·278	23·758
2½	7·8540	4·9087	5⅝	17·671	24·850
2⅝	8·2467	5·4119	5¾	18·064	25·967
2¾	8·6394	5·9395	5⅞	18·457	27·108
2⅞	9·0321	6·4918	6	18·849	28·274
3	9·4248	7·0686	6⅛	19·242	29·464
3⅛	9·8175	7·6699	6¼	19·635	30·679

Diameter.	Circumference.	Area.	Diameter.	Circumference.	Area.
$6\frac{3}{8}$	20·027	31·919	$11\frac{1}{2}$	36·128	103·869
$6\frac{1}{2}$	20·420	33·183	$11\frac{5}{8}$	36·521	106·139
$6\frac{5}{8}$	20·813	34·471	$11\frac{3}{4}$	36·913	108·434
$6\frac{3}{4}$	21·205	35·784	$11\frac{7}{8}$	37·306	110·753
$6\frac{7}{8}$	21·598	37·122	12	37·699	113·097
7	21·991	38·484	$12\frac{1}{8}$	38·091	115·466
$7\frac{1}{8}$	22·383	39·871	$12\frac{1}{4}$	38·484	117·859
$7\frac{1}{4}$	22·776	41·282	$12\frac{3}{8}$	38·877	120·276
$7\frac{3}{8}$	23·169	42·718	$12\frac{1}{2}$	39·270	122·718
$7\frac{1}{2}$	23·562	44·178	$12\frac{5}{8}$	39·662	125·184
$7\frac{5}{8}$	23·954	45·663	$12\frac{3}{4}$	40·055	127·676
$7\frac{3}{4}$	24·347	47·173	$12\frac{7}{8}$	40·448	130·192
$7\frac{7}{8}$	24·740	48·707	13	40·840	132·732
8	25·132	50·265	$13\frac{1}{8}$	41·233	135·297
$8\frac{1}{8}$	25·515	51·848	$13\frac{1}{4}$	41·626	137·886
$8\frac{1}{4}$	25·918	53·456	$13\frac{3}{8}$	42·018	140·500
$8\frac{3}{8}$	26·310	55·088	$13\frac{1}{2}$	42·411	143·139
$8\frac{1}{2}$	26·703	56·745	$13\frac{5}{8}$	42·804	145·802
$8\frac{5}{8}$	27·096	58·426	$13\frac{3}{4}$	43·197	148·489
$8\frac{3}{4}$	27·489	60·132	$13\frac{7}{8}$	43·589	151·201
$8\frac{7}{8}$	27·881	61·862	14	43·982	153·938
9	28·274	63·617	$14\frac{1}{8}$	44·375	156·699
$9\frac{1}{8}$	28·667	65·396	$14\frac{1}{4}$	44 767	159·485
$9\frac{1}{4}$	29·059	67·200	$14\frac{3}{8}$	45·160	162·295
$9\frac{3}{8}$	29·452	69·029	$14\frac{1}{2}$	45·553	165·130
$9\frac{1}{2}$	29·845	70·882	$14\frac{5}{8}$	45·945	167·989
$9\frac{5}{8}$	30·237	72·759	$14\frac{3}{4}$	46·338	170·873
$9\frac{3}{4}$	30·630	74·662	$14\frac{7}{8}$	46·731	173·782
$9\frac{7}{8}$	31·023	76·588	15	47·124	176·715
10	31·416	78·540	$15\frac{1}{8}$	47·516	179·672
$10\frac{1}{8}$	31·808	80·515	$15\frac{1}{4}$	47·909	182·654
$10\frac{1}{4}$	32·201	82·516	$15\frac{3}{8}$	48·302	185·661
$10\frac{3}{8}$	32·594	84·540	$15\frac{1}{2}$	48·694	188·692
$10\frac{1}{2}$	32·986	86·590	$15\frac{5}{8}$	49·087	191·748
$10\frac{5}{8}$	33·379	88·664	$15\frac{3}{4}$	49·480	194·828
$10\frac{3}{4}$	33·772	90·762	$15\frac{7}{8}$	49·872	197·933
$10\frac{7}{8}$	34·164	92·885	16	50·265	201·062
11	34·557	95·033	$16\frac{1}{8}$	50·658	204·216
$11\frac{1}{8}$	34·950	97·205	$16\frac{1}{4}$	51·051	207·394
$11\frac{1}{4}$	35·343	99·402	$16\frac{3}{8}$	51·443	210·597
$11\frac{3}{8}$	35·735	101·623	$16\frac{1}{2}$	51 836	213·825

Diameter.	Circumference.	Area.	Diameter.	Circumference.	Area.
$16\frac{5}{8}$	52·229	217·077	$21\frac{3}{4}$	68·329	371·543
$16\frac{3}{4}$	52·621	220·353	$21\frac{7}{8}$	68·722	375·826
$16\frac{7}{8}$	53·014	223·654	22	69·115	380·133
17	53·407	226·980	$22\frac{1}{8}$	69·507	384·465
$17\frac{1}{8}$	53·799	230·330	$22\frac{1}{4}$	69·900	388·822
$17\frac{1}{4}$	54·192	233·705	$22\frac{3}{8}$	70·293	393·203
$17\frac{3}{8}$	54·585	237·104	$22\frac{1}{2}$	70·686	397·608
$17\frac{1}{2}$	54·978	240·528	$22\frac{5}{8}$	71·078	402·038
$17\frac{5}{8}$	55·370	243·977	$22\frac{3}{4}$	71·471	406·493
$17\frac{3}{4}$	55·763	247·450	$22\frac{7}{8}$	71·864	410·972
$17\frac{7}{8}$	56·156	250·947	23	72·256	415·476
18	56·548	254·469	$23\frac{1}{8}$	72·649	420·004
$18\frac{1}{8}$	56·941	258·016	$23\frac{1}{4}$	73·042	424·557
$18\frac{1}{4}$	57·334	261·587	$23\frac{3}{8}$	73·434	429·135
$18\frac{3}{8}$	57·726	265·182	$23\frac{1}{2}$	73·827	433·731
$18\frac{1}{2}$	58·119	268·803	$23\frac{5}{8}$	74·220	438·363
$18\frac{5}{8}$	58·512	272·447	$23\frac{3}{4}$	74·613	443·014
$18\frac{3}{4}$	58·905	276·117	$23\frac{7}{8}$	75·005	447·699
$18\frac{7}{8}$	59·297	279·811	24	75·398	452·390
19	59·690	283·529	$24\frac{1}{4}$	76·183	461·864
$19\frac{1}{8}$	60·083	287·272	$24\frac{1}{2}$	76·969	471·436
$19\frac{1}{4}$	60·475	291·039	$24\frac{3}{4}$	77·754	481·106
$19\frac{3}{8}$	60·868	294·831	25	78·540	490·875
$19\frac{1}{2}$	61·261	298·648	$25\frac{1}{4}$	79·325	500·741
$19\frac{5}{8}$	61·653	302·489	$25\frac{1}{2}$	80·110	510·706
$19\frac{3}{4}$	62·046	306·355	$25\frac{3}{4}$	80·896	520·769
$19\frac{7}{8}$	62·439	310·245	26	81·681	530·930
20	62·832	314·160	$26\frac{1}{4}$	82·467	541·189
$20\frac{1}{8}$	63·224	318·099	$26\frac{1}{2}$	83·252	551·547
$20\frac{1}{4}$	63·617	322·063	$26\frac{3}{4}$	84·037	562·002
$20\frac{3}{8}$	64·010	326·051	27	84·823	572·556
$20\frac{1}{2}$	64·402	330·064	$27\frac{1}{4}$	85·608	583·208
$20\frac{5}{8}$	64·795	334·101	$27\frac{1}{2}$	86·394	593·958
$20\frac{3}{4}$	65·188	338·163	$27\frac{3}{4}$	87·179	604·807
$20\frac{7}{8}$	65·580	342·250	28	87·964	615·753
21	65·973	346·361	$28\frac{1}{4}$	88·750	626·798
$21\frac{1}{8}$	66·366	350·497	$28\frac{1}{2}$	89·535	637·941
$21\frac{1}{4}$	66·759	354·657	$28\frac{3}{4}$	90·321	649·182
$21\frac{3}{8}$	67·151	358·841	29	91·106	660·521
$21\frac{1}{2}$	67·544	363·051	$29\frac{1}{4}$	91·891	671·958
$21\frac{5}{8}$	67·937	367·284	$29\frac{1}{2}$	92·677	683·494

Diameter.	Circumference.	Area.	Diameter.	Circumference.	Area.
29¾	93·462	695·128	40	125·664	1256·64
30	94·248	706·860	40¼	126·449	1272·39
30¼	95·033	718·690	40½	127·234	1288·25
30½	95·818	730·618	40¾	128·020	1304·20
30¾	96·604	742·644	41	128·805	1320·25
31	97·389	754·769	41¼	129·591	1336·40
31¼	98·175	766·992	41½	130·376	1352·65
31½	98·968	779·313	41¾	131·161	1369·00
31¾	99·745	791·732	42	131·947	1385·44
32	100·531	804·249	42¼	132·732	1401·98
32¼	101·316	816·865	42½	133·518	1418·62
32½	102·102	829·578	42¾	134·303	1435·36
32¾	102·887	842·390	43	135·088	1452·20
33	103·672	855·30	43¼	135·874	1469·13
33¼	104·458	868·30	43½	136·659	1486·17
33½	105·243	881·41	43¾	137·445	1503·30
33¾	106·029	894·61	44	138·230	1520·53
34	106·814	907·92	44¼	139·015	1537·86
34¼	107·599	921·32	44½	139·801	1555·28
34½	108·385	934·82	44¾	140·586	1572·81
34¾	109·170	948·41	45	141·372	1590·43
35	109·956	962·11	45¼	142·157	1608·15
35¼	110·741	975·90	45½	142·942	1625·97
35½	111·526	989·80	45¾	143·728	1643·89
35¾	112·312	1003·78	46	144·513	1661·90
36	113·097	1017·87	46¼	145·299	1680·01
36¼	113·883	1032·06	46½	146·084	1698·23
36½	114·668	1046·35	46¾	146·869	1716·54
36¾	115·453	1060·73	47	147·655	1734·94
37	116·239	1075·21	47¼	148·440	1753·45
37¼	117·024	1089·79	47½	149·226	1772·05
37½	117·810	1104·46	47¾	150·011	1790·76
37¾	118·595	1119·24	48	150·796	1809·56
38	119·380	1134·11	48¼	151·582	1828·46
38¼	120·166	1149·08	48½	152·367	1847·45
38½	120·951	1164·15	48¾	153·153	1866·55
38¾	121·737	1179·32	49	153·938	1885·74
39	122·522	1194·59	49¼	154·723	1905·03
39¼	123·307	1209·95	49½	155·509	1924·42
39½	124·093	1225·42	49¾	156·294	1943·91
39¾	124·878	1240·98	50	157·080	1963·50

Diameter.	Circumference.	Area.	Diameter.	Circumference.	Area.
50¼	157·865	1983·18	60½	190·066	2874·76
50½	158·650	2002·96	60¾	190·852	2898·56
50¾	159·436	2022·84	61	191·637	2922·47
51	160·221	2042·82	61¼	192·423	2946·47
51¼	161·007	2062·90	61½	193·208	2970·57
51½	161·792	2083·07	61¾	193·993	2994·77
51¾	162·577	2103·35	62	194·779	3019·07
52	163·363	2123·72	62¼	195·564	3043·47
52¼	164·148	2144·19	62½	196·350	3067·96
52½	164·934	2164·75	62¾	197·135	3092·56
52¾	165·719	2185·42	63	197·920	3117.25
53	166·504	2206·18	63¼	198·706	3142·04
53¼	167·290	2227·05	63½	199·491	3166·92
53½	168·075	2248·01	63¾	200·277	3191·91
53¾	168·861	2269·06	64	201·062	3216·99
54	169·646	2290·22	64¼	201·847	3242·17
54¼	170·431	2311·48	64½	202·633	3267·46
54½	171·217	2332·83	64¾	203·418	3292·83
54¾	172·002	2354·28	65	204·204	3318·31
55	172·788	2375·83	65¼	204·989	3343·88
55¼	173·573	2397·48	65½	205·774	3369·56
55½	174·358	2419·22	65¾	206·560	3395·33
55¾	175·144	2441·07	66	207·345	3421·20
56	175·929	2463·01	66¼	208·131	3447·16
56¼	176·715	2485·05	66½	208·916	3473·23
56½	177·500	2507·19	66¾	209·701	3499·39
56¾	178·285	2529·42	67	210·487	3525·66
57	179·071	2551·76	67¼	211·272	3552·01
57¼	179·856	2574·19	67½	212·058	3578·47
57½	180·642	2596·72	67¾	212·843	3605·03
57¾	181·427	2619·35	68	213·628	3631·68
58	182·212	2642·08	68¼	214·414	3658·44
58¼	182·998	2664·91	68½	215·199	3685·29
58½	183·783	2687·83	68¾	215·985	3712·24
58¾	184·569	2710·85	69	216·770	3739·28
59	185·354	2733·97	69¼	217·555	3766·43
59¼	186·139	2757·19	69½	218·341	3793·67
59½	186·925	2780·51	69¾	219·126	3821·02
59¾	187·710	2803·92	70	219·912	3848·46
60	188·496	2827·44	70¼	220·697	3875·99
60¼	189·281	2851·05	70½	221·482	3903·63

Diameter.	Circumference.	Area.	Diameter.	Circumference.	Area.
70 3/4	222·268	3931·36	81	254·469	5153·00
71	223·053	3959·20	81 1/4	255·254	5184·84
71 1/4	223·839	3987·13	81 1/2	256·040	5216·82
71 1/2	224·624	4015·16	81 3/4	256·825	5248·84
71 3/4	225·409	4043·28	82	257·611	5281·02
72	226·195	4071·51	82 1/4	258·396	5313·28
72 1/4	226·980	4099·83	82 1/2	259·182	5345·62
72 1/2	227·766	4128·25	82 3/4	259·967	5378·04
72 3/4	228·551	4156·77	83	260·752	5410·62
73	229·336	4185·39	83 1/4	261·537	5443·24
73 1/4	230·122	4214·11	83 1/2	262·323	5476·00
73 1/2	230·907	4242·92	83 3/4	263·108	5508·84
73 3/4	231·693	4271·83	84	263·894	5541·78
74	232·478	4300·85	84 1/4	264·679	5574·80
74 1/4	233·263	4329·95	84 1/2	265·465	5607·95
74 1/2	234·049	4359·16	84 3/4	266·250	5641·16
74 3/4	234·834	4388·47	85	267·036	5674·51
75	235·620	4417·87	85 1/4	267·821	5707·92
75 1/4	236·405	4447·37	85 1/2	268·606	5741·47
75 1/2	237·190	4476·97	85 3/4	269·392	5775·09
75 3/4	237·976	4506·67	86	270·177	5808·81
76	238·761	4536·47	86 1/4	270·962	5842·60
76 1/4	239·547	4566·36	86 1/2	271·748	5876·55
76 1/2	240·332	4596·35	86 3/4	272·533	5910·52
76 3/4	241·117	4626·44	87	273·319	5944·69
77	241·903	4656·63	87 1/4	274·104	5978·88
77 1/4	242·688	4686·92	87 1/2	274·890	6013·21
77 1/2	243·474	4717·30	87 3/4	275·675	6047·60
77 3/4	244·259	4747·79	88	276·460	6082·13
78	245·044	4778·37	88 1/4	277·245	6116·72
78 1/4	245·830	4809·05	88 1/2	278·031	6151·44
78 1/2	246·615	4839·83	88 3/4	278·816	6186·20
78 3/4	247·401	4870·70	89	279·602	6221·15
79	248·186	4901·68	89 1/4	280·387	6256·12
79 1/4	248·971	4932·75	89 1/2	281·173	6291·25
79 1/2	249·757	4963·92	89 3/4	281·958	6326·44
79 3/4	250·542	4995·19	90	282·744	6361·74
80	251·328	5026·56	90 1/4	283·529	6399·12
80 1/4	252·113	5058·00	90 1/2	284·314	6432·62
80 1/2	252·898	5089·58	90 3/4	285·099	6468·16
80 3/4	253·683	5121·22	91	285·885	6503·89

Diameter.	Circumference.	Area.	Diameter.	Circumference.	Area.
91¼	286·670	6539·68	93¾	294·524	6882·92
91½	287·456	6573·56	94	295·310	6939·79
91¾	288·242	6611·52	94¼	296·095	6976·72
92	289·027	6647·62	94½	296·881	7013·81
92¼	289·812	6683·80	94¾	297·666	7050·92
92½	290·598	6720·07	95	298·452	7088·23
92¾	291·383	6756·40	95¼	299·237	7125·56
93	292·168	6792·92	95½	300·022	7163·04
93¼	292·953	6829·48	95¾	300·807	7200·56
93½	293·739	6866·16	96	301·593	7238·24

Table of Squares, Cubes, Square Roots, and Cube Roots.

Number.	Square.	Cube.	Square Root.	Cube Root.
1	1	1	1·0	1·0
2	4	8	1·41421	1·2599
3	9	27	1·73205	1·4423
4	16	64	2·0	1·5874
5	25	125	2·23607	1·7099
6	36	216	2·44949	1·8171
7	49	343	2·64575	1·9129
8	64	512	2·82843	2·0
9	81	729	3·0	2·0801
10	100	1000	3·16228	2·1544
11	121	1331	3·31663	2·2239
12	144	1728	3·46410	2·2894
13	169	2197	3·60555	2·3513
14	196	2744	3·74166	2·4101
15	225	3375	3·87298	2·4662
16	256	4096	4·0	2·5198
17	289	4913	4·12311	2·5713
18	324	5832	4·24264	2·6207
19	361	6859	4·35890	2·6684
20	400	8000	4·47214	2·7144

Number.	Square.	Cube.	Square Root.	Cube Root.
21	441	9261	4·58258	2·7589
22	484	10648	4·69042	2·8020
23	529	12167	4·79583	2·8439
24	576	13824	4·89898	2·8845
25	625	15625	5·0	2·9240
26	676	17576	5·09902	2·9625
27	729	19683	5·19615	3·0
28	784	21952	5·29150	3·0366
29	841	24389	5·38517	3·0723
30	900	27000	5·47723	3·1072
31	961	29791	5·56776	3·1414
32	1024	32768	5·65685	3·1748
33	1089	35937	5·74456	3·2075
34	1156	39304	5·83095	3·2396
35	1225	42875	5·91608	3·2711
36	1296	46656	6·0	3·3019
37	1369	50653	6·08276	3·3322
38	1444	54872	6·16441	3·3619
39	1521	59319	6·245	3·3912
40	1600	64000	6·32456	3·4199
41	1681	68921	6·40312	3·4482
42	1764	74088	6·48074	3·4760
43	1849	79507	6·55744	3·5034
44	1936	85184	6·63325	3·5303
45	2025	91125	6·70820	3·5569
46	2116	97336	6·78230	3·5830
47	2209	103823	6·85566	3·6088
48	2304	110592	6·92820	3·6342
49	2401	117649	7·0	3·6593
50	2500	125000	7·07107	3·6840
51	2601	132651	7·14143	3·7084
52	2704	140608	7·21110	3·7325
53	2809	148877	7·28011	3·7563
54	2916	157464	7·34847	3·7798
55	3025	166375	7·4162	3·8029
56	3136	175616	7·48332	3·8259
57	3249	185193	7·54983	3·8485
58	3364	195112	7·61577	3·8709
59	3481	205379	7·68115	3·8930
60	3600	216000	7·74597	3·9149
61	3721	226981	7·81025	3·9365
62	3844	238328	7·87401	3·9579

Number.	Square.	Cube.	Square Root.	Cube Root.
63	3969	250047	7·93725	3·9791
64	4096	262144	8·0	4·0
65	4225	274625	8·06226	4·0207
66	4356	287496	8·12404	4·0412
67	4489	300763	8·18535	4·0615
68	4624	314432	8·24621	4·0817
69	4761	328509	8·30662	4·1016
70	4900	343000	8·36660	4·1213
71	5041	357911	8·42615	4·1408
72	5184	373248	8·48528	4·1602
73	5329	389017	8·54400	4·1793
74	5476	405224	8·60233	4·1983
75	5625	421875	8·66025	4·2172
76	5776	438976	8·71779	4·2358
77	5929	456533	8·77496	4·2543
78	6084	474552	8·83176	4·2727
79	6241	493039	8·88819	4·2908
80	6400	512000	8·944	4·3089
81	6561	531441	9·0	4·3267
82	6724	551368	9·05589	4·3445
83	6889	571787	9·11043	4·3621
84	7056	592704	9·16515	4·3795
85	7225	614125	9·21955	4·3968
86	7396	636056	9·27362	4·4141
87	7569	658503	9·32738	4·4314
88	7744	681472	9·38083	4·4479
89	7921	704969	9·43398	4·4647
90	8100	729000	9·48683	4·4814
91	8281	753571	9·53939	4·4979
92	8464	778688	9·59166	4·5144
93	8649	804357	9·64365	4·5307
94	8836	830584	9·69536	4·5468
95	9025	857375	9·74679	4·5629
96	9216	884736	9·79796	4·5789
97	9409	912673	9·84886	4·5947
98	9604	941192	9·89949	4·6104
99	9801	970299	9·94987	4·6261
100	10000	1000000	10·0	4·6416

Table of the Weight of Cast-iron Balls.

Diam. in inches.	Weight in lbs.	Diam. in inches.	Weight in lbs.	Diam. in inches.	Weight in lbs.
2	1·10	6	29·72	10	137·71
2¼	1·57	6¼	33·62	10¼	148·28
2½	2·15	6½	37·80	10½	159·40
2¾	2·86	6¾	42·35	10¾	171·05
3	3·72	7	47·21	11	183·29
3¼	4·71	7¼	52·47	11¼	196·10
3½	5·80	7½	58·06	11½	209·43
3¾	7·26	7¾	64·09	11¾	223·40
4	8·81	8	70·49	12	237·94
4¼	10·57	8¼	77·32	12¼	253·13
4½	12·55	8½	84·56	12½	268·97
4¾	14·76	8¾	92·24	12¾	285·37
5	17·12	9	100·39	13	302·41
5¼	19·93	9¼	108·98	13¼	320·80
5½	22·91	9½	118·06	13½	338·81
5¾	26·18	9¾	127·63	13¾	357·93

Table of Dimensions for Pipe Flanges and Sockets.

Diameter of Pipe.	Diameter of Flange.	Thickness of Flange.	No. of Bolts.	Bore of Socket.	Depth of Socket.
Inches.	Inches.	Inches.		Inches.	Inches.
2	6 to 6½	½	4	3¼	2¾
3	7½ ,, 8	⅝	4	4½	3
4	8½ ,, 9	¾	4	5¾	3½
5	10 ,, 10½	¾	6	6¾	4
6	11 ,, 11½	¾	6	7¾	4½
7	12 ,, 13	⅞	6	8¾	4½
8	13 ,, 14	⅞	6	9¾	4½
9	14 ,, 15	⅞	6	11	4½
10	16	1	6	12	4½
11	17	1	6	13	4½
12	18	1	6	14	4½

The above dimensions are good, but not arbitrary. The usages of manufacturers differ, some making their flanges smaller, others larger than these. Obviously, too, the proportions and the number of bolts and flanges will vary with the strains the pipes have to bear.

Table of Decimal Equivalents. One Inch the Integer.

·96875	= 7/8 and 3/32		·46875	= 3/8 and 3/32	
·9375	= 7/8 ,, 1/16		·4375	= 3/8 ,, 1/16	
·90625	= 7/8 ,, 1/32		·40625	= 3/8 ,, 1/32	
·875	= 7/8		·375	= 3/8	
·84375	= 3/4 ,, 3/32		·34375	= 1/4 ,, 3/32	
·8125	= 3/4 ,, 1/16		·3125	= 1/4 ,, 1/16	
·78125	= 3/4 ,, 1/32		·28125	= 1/4 ,, 1/32	
·75	= 3/4		·25	= 1/4	
·71875	= 5/8 ,, 3/32		·21875	= 1/8 ,, 3/32	
·6875	= 5/8 ,, 1/16		·1875	= 1/8 ,, 1/16	
·65625	= 5/8 ,, 1/32		·15625	= 1/8 ,, 1/32	
·625	= 5/8		·125	= 1/8	
·59375	= 1/2 ,, 3/32		·09375	= 3/32	
·5625	= 1/2 ,, 1/16		·0625	= 1/16	
·53125	= 1/2 ,, 1/32		·03125	= 1/32	
·5	= 1/2				

Table of Decimal Equivalents. One Foot the Integer.

·9166	= 11 inches.	·1666	= 2 inches.
·6338	= 10 ,,	·0833	= 1 inch.
·75	= 9 ,,	·07291	= 7/8 of inch.
·6666	= 8 ,,	·0625	= 3/4 ,,
·5833	= 7 ,,	·05208	= 5/8 ,,
·5	= 6 ,,	·04166	= 1/2 ,,
·4166	= 5 ,,	·03125	= 3/8 ,,
·3333	= 4 ,,	·02083	= 1/4 ,,
·25	= 3 ,,	·01041	= 1/8 ,,

Table of the Weight of Solid Cylinders in Cast Iron, One Foot long.

	Diameters in inches.								
	1	2	3	4	5	6	7	8	9
Weight in lbs.	2·4	9·9	21·9	39·0	61·0	89·0	120·0	156·0	198·0

Length of Chords for Spacing a Circle of One Inch Diameter.

(For spacing other circles, multiply diameter by length below.)

Number of Spaces.	Length of Chord.	Number of Spaces.	Length of Chord.	Number of Spaces.	Length of Chord.
3	·8660	36	·0872	69	·0455
4	·7071	37	·0848	70	·0449
5	·5878	38	·0826	71	·0442
6	·5000	39	·0805	72	·0436
7	·4339	40	·0785	73	·0430
8	·3827	41	·0765	74	·0424
9	·3420	42	·0747	75	·0419
10	·3090	43	·0730	76	·0413
11	·2817	44	·0713	77	·0408
12	·2588	45	·0698	78	·0403
13	·2393	46	·0682	79	·0398
14	·2225	47	·0668	80	·0393
15	·2079	48	·0654	81	·0388
16	·1951	49	·0641	82	·0383
17	·1838	50	·0628	83	·0378
18	·1736	51	·0616	84	·0374
19	·1646	52	·0604	85	·0370
20	·1564	53	·0592	86	·0365
21	·1490	54	·0581	87	·0361
22	·1423	55	·0571	88	·0357
23	·1362	56	·0561	89	·0353
24	·1305	57	·0551	90	·0349
25	·1353	58	·0541	91	·0345
26	·1205	59	·0532	92	·0341
27	·1161	60	·0532	93	·0338
28	·1120	61	·0523	94	·0334
29	·1081	62	·0515	95	·0331
30	·1045	63	·0507	96	·0327
31	·1012	64	·0499	97	·0324
32	·0980	65	·0491	98	·0321
33	·0951	66	·0483	99	·0317
34	·0923	67	·0469	100	·0314
35	·0896	68	·0462		

Wood Screws.					
Screw No.	Screw Diameter.	Clearance Hole.		Tapping Drill.	Approximate Diameter of Head.
		Drilled.	Punched.		
1	·066	·078	·077	·052	·134
2	·080	·093	·088	·059	·164
3	·094	·106	·101	·073	·184
4	·108	·120	·115	·086	·215
5	·122	·136	·134	·0995	·246
6	·136	·149	·146	·110	·272
7	·150	·166	·164	·125	·300
8	·164	·180	·172	·136	·328
9	·178	·196	·188	·147	·360
10	·192	·213	·212	·157	·384
12	·224	·242	·240	·182	·440
14	·250	·272	·269	·201	·500

Specific Gravity and Density of Materials.

Material.	Specific Gravity.	Density. Lbs./Cub. Ft.
Water at 4° C. - -	1·0	62·42
Aluminium (cast) -	2·6	161·7
Brass - - - -	3·1	503·0
Copper - - -	8·79	545·0
Iron (cast) - - -	7·5	465·0
Iron (wrought) - -	7·74	483·0
Lead - - - -	11·35	708·0
Nickel - - -	8·9	547·0
Steel - - - -	7·83	486·0
Tin - - - -	7·29	452·0
Zinc - - - -	7·19	445·0
Pine (white) - -	0·55	34·6

Weights of Timber in Pounds per Cubic Foot.

Timber.	Weight.
White pine - - - -	28 lbs.
Spruce fir - - - -	31 ,,
Larch - - - - -	35 ,,
Honduras mahogany - -	35 ,,
Spanish mahogany - - -	53 ,,
Elm - - - - -	37 ,,
American red pine - - -	37 ,,
Northern pine - - -	37 ,,
Kauri pine - - - -	38 ,,
Ash - - - - -	45 ,,
Beech - - - - -	47 ,,
Baltic oak - - - -	48 ,,
English oak - - - -	50 ,,
Pitch pine - - - -	50 ,,
Teak - - - - -	50 ,,
Greenheart - - - -	60 ,,

Decimal Equivalents of Twist Drill Numbers.

No.	Diameter.	No.	Diameter.
1	·2280	31	·1200
2	·2210	32	·1160
3	·2130	33	·1130
4	·2090	34	·1110
5	·2055	35	·1100
6	·2040	36	·1065
7	·2010	37	·1040
8	·1990	38	·1015
9	·1960	39	·0995
10	·1935	40	·0980
11	·1910	41	·0960
12	·1890	42	·0935
13	·1850	43	·0890
14	·1820	44	·0860
15	·1800	45	·0820
16	·1770	46	·0810
17	·1730	47	·0785
18	·1695	48	·0760
19	·1660	49	·0730
20	·1610	50	·0700
21	·1590	51	·0670
22	·1570	52	·0635
23	·1540	53	·0595
24	·1520	54	·0550
25	·1495	55	·0520
26	·1470	56	·0465
27	·1440	57	·0430
28	·1405	58	·0420
29	·1360	59	·0410
30	·1285	60	·0400

Tapers per Foot and Included Angle.

Taper per Foot.	Included Angle.	Taper per Foot.	Included Angle.
$\frac{1}{8}$ inch.	0° 36′	$2\frac{1}{2}$ inches.	11° 54′
$\frac{1}{4}$,,	1° 12′	3 ,,	14° 16′
$\frac{5}{16}$,,	1° 30′	$3\frac{1}{2}$,,	16° 36′
$\frac{3}{8}$,,	1° 47′	4 ,,	18° 54′
$\frac{7}{16}$,,	2° 5′	$4\frac{1}{2}$,,	21° 14′
$\frac{1}{2}$,,	2° 23′	5 ,,	23° 32′
$\frac{3}{4}$,,	3° 35′	6 ,,	28° 4′
$\frac{15}{16}$,,	4° 28′	7 ,,	32° 31′
1 ,,	4° 45′	8 ,,	36° 52′
$1\frac{1}{2}$,,	7° 8′	9 ,,	41° 7′
$1\frac{3}{4}$,,	8° 20′	10 ,,	45° 14′
2 ,,	9° 32′	11 ,,	49° 15′

Table of Cone Angles.

Cone.	Degrees.	Cone.	Degrees.
1 in 2	$28\frac{1}{12}$	1 in 9	$6\frac{1}{3}$
1 ,, $2\frac{1}{4}$	25	1 ,, $9\frac{1}{2}$	6
1 ,, $2\frac{1}{2}$	$22\frac{2}{3}$	1 ,, 10	$5\frac{2}{3}$
1 ,, $2\frac{3}{4}$	$20\frac{1}{2}$	1 ,, $10\frac{1}{2}$	$5\frac{1}{2}$
1 ,, 3	19	1 ,, 11	$5\frac{1}{5}$
1 ,, $3\frac{1}{4}$	$17\frac{1}{2}$	1 ,, $11\frac{1}{2}$	5
1 ,, $3\frac{1}{2}$	$16\frac{1}{4}$	1 ,, 12	$4\frac{3}{4}$
1 ,, $3\frac{3}{4}$	$15\frac{1}{6}$	1 ,, $12\frac{1}{2}$	$4\frac{3}{5}$
1 ,, 4	$14\frac{1}{4}$	1 ,, 13	$4\frac{1}{2}$
1 ,, $4\frac{1}{4}$	$13\frac{2}{5}$	1 ,, $13\frac{1}{2}$	$4\frac{1}{4}$
1 ,, $4\frac{1}{2}$	$12\frac{2}{3}$	1 ,, 14	$4\frac{1}{12}$
1 ,, $4\frac{3}{4}$	12	1 ,, $14\frac{1}{2}$	4
1 ,, 5	$11\frac{2}{5}$	1 ,, 15	$3\frac{3}{4}$
1 ,, $5\frac{1}{4}$	$10\frac{5}{16}$	1 ,, 16	$3\frac{3}{5}$
1 ,, $5\frac{1}{2}$	$10\frac{1}{3}$	1 ,, 17	$3\frac{2}{5}$
1 ,, $5\frac{3}{4}$	10	1 ,, 18	$3\frac{1}{6}$
1 ,, 6	$9\frac{1}{2}$	1 ,, 19	3
1 ,, $6\frac{1}{2}$	$8\frac{4}{5}$	1 ,, 20	$2\frac{5}{6}$
1 ,, 7	$8\frac{1}{6}$	1 ,, 25	$2\frac{1}{4}$
1 ,, $7\frac{1}{2}$	$7\frac{2}{3}$	1 ,, 30	2
1 ,, 8	$7\frac{1}{16}$	1 ,, 35	$1\frac{3}{5}$
1 ,, $8\frac{1}{2}$	$6\frac{3}{4}$	1 ,, 40	$1\frac{2}{5}$

APPENDIX.

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